YAMAHA ROBOT CONTROLLER

Safety standards application guide

Reference Manual

CE

RCX340/RCX240/RCX221/RCX222
SR1-X/SR1-P

KCs

RCX240

Ver. 1.00

EXX1148100
E120

General Contents

Introduction i

Safety Instructions

1. Safety Information S-1

2. Signal words used in this manual S-2

3. Warning labels S-3

3.1 Warning labels S-3

3.1.1 Warning label messages on robot and controller S-3

3.1.2 Supplied warning labels S-7

3.2 Warning symbols S-8

4. Important precautions for each stage of the robot life cycle S-9

4.1 Precautions for using robots and controllers S-9

4.2 Essential precautions for the linear conveyor module S-10

4.3 Design S-11

4.3.1 Precautions for robots S-11

4.3.2 Precautions for robot controllers S-11

4.4 Moving and installation S-12

4.4.1 Precautions for robots S-12

4.4.2 Precautions for robot controllers S-13

4.5 Safety measures S-15

4.5.1 Safety measures S-15

4.5.2 Installing a safety enclosure S-16

4.6 Operation S-17

4.6.1 Trial operation S-17

4.6.2 Automatic operation S-19

4.6.3 Precautions during operation S-19

4.7 Inspection and maintenance S-21

4.7.1 Before inspection and maintenance work S-21

4.7.2 Precautions during service work S-22

4.8 Disposal S-23

5. Emergency action when a person is caught by robot S-24

6. Cautions regarding strong magnetic fields S-24

7. Using the robot safely S-25

7.1 Movement range S-25

7.2 Robot protective functions S-26

7.3 Residual risk S-27

7.4 Special training for industrial robot operation S-27

Chapter 1 Measures for each country's safety standards

1. Overview 1-1

2. Safety standards 1-2

2.1 Measures for CE marking 1-2

2.1.1 Cautions regarding compliance with EC Directives 1-2
2.1.2 CE marking 1-2
2.1.3 Applicable EC Directives and their related standards 1-3
2.1.4 Robots subject to CE Marking 1-3
2.1.5 Cautions regarding the official language of EU countries 1-3

2.2 Measures for KCs 1-4

2.2.1 Cautions regarding compliance with KCs 1-4
2.2.2 KCs mark 1-4
2.2.3 Normative standards 1-4
2.2.4 Robots subject to KCs 1-5

3. Usage conditions 1-6

Chapter 2 RCX series

1. System overview 2-1

1.1 System overview 2-1

1.1.1 Main system configuration 2-1

1.2 Control system configuration 2-4

1.2.1 Basic configuration 2-4
1.2.2 Power supply and emergency stop system circuit configuration 2-8

1.3 Programming box 2-9

1.3.1 PBX-E 2-9
1.3.1.1 Part names and functions 2-9
1.3.1.2 PB connector 2-10
1.3.2 RPB-E 2-11
1.3.2.1 Part names and functions 2-11
1.3.2.2 RPB connector 2-12

1.4 CE specifications and KCs specifications 2-14

1.4.1 MANUAL mode (Applicable controller: RCX340) 2-14
1.4.1.1 MANUAL mode parameter settings 2-15
1.4.2 SERVICE mode (Applicable controller: RCX240/221/222/SR1) 2-16
1.4.2.1 Flow for enabling the SERVICE mode functions 2-17
1.4.2.2 SERVICE mode parameter settings 2-17

2. EMC countermeasure examples 2-19

2.1 RCX340 2-19

2.1.1 Configuration 2-19
2.1.2 Countermeasure components 2-20

2.2 RCX240 2-22

2.2.1 Configuration 2-22
2.2.2 Countermeasure components 2-23

2.3 RCX221/RCX222 2-26

2.3.1 Configuration 2-26
2.3.2 Countermeasure components 2-27

3. External safety circuit examples 2-30

3.1 Safety requirements 2-30

3.1.1 CE marking 2-30
3.1.2 KCs mark 2-30

3.2 Circuit examples for the RCX340 2-31

3.2.1 Category 3 2-31
3.2.2 Overview of circuit operation 2-32

3.3 Circuit examples for the RCX240 2-33

3.3.1 Category 3 2-33
3.3.2 Overview of circuit operation 2-34

3.4 Circuit examples for the RCX221/RCX222 2-35

3.4.1 Category 4 2-37
3.4.2 Category 3 2-38
3.4.3 Category 2 2-39
3.4.4 Overview of circuit operation 2-40

Chapter 3 SR1 series

1. System overview 3-1

1.1 System overview 3-1

1.1.1 Main system configuration 3-1

1.2 Control system configuration 3-2

1.2.1 Basic configuration 3-2
1.2.2 Power supply and emergency stop system circuit configuration 3-3

1.3 Programming box (HPB-D) 3-4

1.3.1 Part names and functions 3-4
1.3.2 HPB connector and HPB-D SAFETY connector 3-5

1.4 SERVICE mode 3-6

1.4.1 What is SERVICE mode? 3-6
1.4.2 Flow for enabling the SERVICE mode functions 3-6
1.4.3 Limiting functions in SERVICE mode 3-7

2. EMC countermeasure examples 3-8

2.1 SR1 3-8

2.1.1 Configuration 3-8
2.1.2 Countermeasure components 3-9

3. External safety circuit examples 3-12

3.1 Safety requirements 3-12

3.1.1 CE marking 3-12

3.2 Circuit examples for the SR1 3-13

3.2.1 Category 4 3-15
3.2.2 Category 3 3-16
3.2.3 Category 2 3-17
3.2.4 Overview of circuit operation 3-18

Introduction

Thanks for purchasing the YAMAHA robot controller RCX340/RCX240/RCX221/RCX222/SR1-X/SR1-P.

This manual describes the contents of the measures for the safety standards for the RCX340/RCX240/RCX221/RCX222/SR1-X/SR1-P to be installed in each country.
When shipping or using the RCX240/RCX221/RCX222/SR1-X/SR1-P overseas, always read this manual thoroughly to operate the controller correctly.
Note that this manual describes only the contents of the measures for each country's safety standards.
For operations and programming of the robot controller, refer to the user's manuals that come with the robot controller. For information on the warranty, also refer to the user's manuals that come with the robot controller.
Even after reading this manual, keep it in a safe, easily accessible place so that it can be referred to when needed.

- This manual should be used with the robot and controller and considered an integral part of them.
- When the robot and controller are moved, transferred, or sold, send this manual to the new user along with the robot and controller. Be sure to explain to the new user the need to read through this manual.
- Specifications of the robot and controller models other than standard models may be omitted in this manual. In that case, refer to the specifications of standard models.
- For details on specific operation of the robot controller, refer to the user's manuals that come with the robot controller.

NOTES

◆The contents of this manual are subject to change without prior notice.

◆While every effort has been made to ensure the contents of this manual are correct, please contact us if you find any part of this manual to be unclear, confusing or inaccurate.

◆This manual does not serve as a guarantee of any industrial property rights or any other rights and does not grant a license in any form. Please acknowledge that we bear no liability whatsoever for any problems involving industrial property rights which may arise from the contents of this manual.

YAMAHA MOTOR CO., LTD.
IM Operations

Safety Instructions

Contents

1. Safety Information S-1
2. Signal words used in this manual S-2
3. Warning labels S-3
3.1 Warning labels S-3
3.1.1 Warning label messages on robot and controller S-3
3.1.2 Supplied warning labels S-7
3.2 Warning symbols S-8
4. Important precautions for each stage of the robot life cycle S-9
4.1 Precautions for using robots and controllers S-9
4.2 Essential precautions for the linear conveyor module S-10
4.3 Design S-11
4.3.1 Precautions for robots S-11
4.3.2 Precautions for robot controllers S-11
4.4 Moving and installation S-12
4.4.1 Precautions for robots S-12
4.4.2 Precautions for robot controllers S-13
4.5 Safety measures S-15
4.5.1 Safety measures S-15
4.5.2 Installing a safety enclosure S-16
4.6 Operation S-17
4.6.1 Trial operation S-17
4.6.2 Automatic operation S-19
4.6.3 Precautions during operation S-19
4.7 Inspection and maintenance S-21
4.7.1 Before inspection and maintenance work S-21
4.7.2 Precautions during service work S-22
4.8 Disposal S-23
5. Emergency action when a person is caught by robot S-24
6. Cautions regarding strong magnetic fields S-24
7. Using the robot safely S-25
7.1 Movement range S-25
7.2 Robot protective functions S-26
7.3 Residual risk S-27
7.4 Special training for industrial robot operation S-27

1. Safety Information

Industrial robots are highly programmable, mechanical devices that provide a large degree of freedom when performing various manipulative tasks. To ensure safe and correct use of YAMAHA industrial robots and controllers, carefully read and comply with the safety instructions and precautions in this "Safety Instructions" guide. Failure to take necessary safety measures or incorrect handling may result in trouble or damage to the robot and controller, and also may cause personal injury (to installation personnel, robot operator or service personnel) including fatal accidents.

Before using this product, read this manual and related manuals and take safety precautions to ensure correct handling.
The precautions listed in this manual relate to this product. To ensure safety of the user's final system that includes YAMAHA robots, please take appropriate safety measures as required by the user's individual system.

To use YAMAHA robots and controllers safely and correctly, always comply with the safety rules and instructions.

- For specific safety information and standards, refer to the applicable local regulations and comply with the instructions.
- Warning labels attached to the robots are written in English, Japanese, Chinese and Korean. This manual is available in English or Japanese (or some parts in Chinese). Unless the robot operators or service personnel understand these languages, do not permit them to handle the robot.
- Cautions regarding the official language of EU countries
  For equipment that will be installed in EU countries, the language used for the manuals, warning labels, operation screen characters, and CE declarations is English only.
  Warning labels only have pictograms or else include warning messages in English. In the latter case, messages in Japanese or other languages might be added.

It is not possible to list all safety items in detail within the limited space of this manual. So please note that it is essential that the user have a full knowledge of safety and also make correct judgments on safety procedures.

Refer to the manual by any of the following methods when installing, operating or adjusting the robot and controller.

1. Install, operate or adjust the robot and controller while referring to the printed version of the manual (available for an additional fee).
2. Install, operate or adjust the robot and controller while viewing the CD-ROM version of the manual on your computer screen.
3. Install, operate or adjust the robot and controller while referring to a printout of the necessary pages from the CD-ROM version of the manual.

2. Signal words used in this manual

This manual uses the following safety alert symbols and signal words to provide safety instructions that must be observed and to describe handling precautions, prohibited actions, and compulsory actions. Make sure you understand the meaning of each symbol and signal word and then read this manual.

DANGER

This indicates an immediately hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

This indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

This indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury, or damage to the equipment.

NOTE

Explains the key point in the operation in a simple and clear manner.

3. Warning labels

Warning labels shown below are attached to the robot body and controller to alert the operator to potential hazards. To ensure correct use, read the warning labels and comply with the instructions.

3.1 Warning labels

WARNING

If warning labels are removed or difficult to see, then the necessary precautions may not be taken, resulting in an accident.

- **Do not remove, alter or stain the warning labels on the robot body.**
- **Do not allow warning labels to be hidden by devices installed on the robot by the user.**
- **Provide proper lighting so that the symbols and instructions on the warning labels can be clearly seen from outside the safety enclosure.**

3.1.1 Warning label messages on robot and controller

Word messages on the danger, warning and caution labels are concise and brief instructions. For more specific instructions, read and follow the "Instructions on this label" described on the right of each label shown below. See “7.1 Movement range” in “Safety instructions” for details on the robot’s movement range.

■ Warning label 1 (SCARA robots, Cartesian robots)

DANGER

Serious injury may result from contact with a moving robot.

- **Keep outside of the robot safety enclosure during operation.**
- **Press the emergency stop button before entering the safety enclosure.**

Instructions on this label
• Always install a safety enclosure to keep all persons away from the robot movement range and prevent injury from contacting the moving part of the robot. • Install an interlock that triggers emergency stop when the door or gate of the safety enclosure is opened. • The safety enclosure should be designed so that no one can enter inside except from the door or gate equipped with an interlock device. • Warning label 1 that comes supplied with a robot should be affixed to an easy-to-see location on the door or gate of the safety enclosure.

Potential hazard to human body	Serious injury may result from contact with a moving robot.
To avoid hazard	• Keep outside of the robot safety enclosure during operation. • Press the emergency stop button before entering the safety enclosure.

90K41-001470

■ Warning label 2 (SCARA robots, Cartesian robots, single-axis robots*)

* Warning label 2 is not attached to some small single-axis robots, but is supplied with the robots.

WARNING

Moving parts can pinch or crush hands.
Keep hands away from the movable parts of the robot.

Instructions on this label
Use caution to prevent hands and fingers from being pinched or crushed by the movable parts of the robot when transporting or moving the robot or during teaching.

Potential hazard to human body	Moving parts can pinch or crush hands.
To avoid hazard	Keep hands away from the movable parts of the robot.

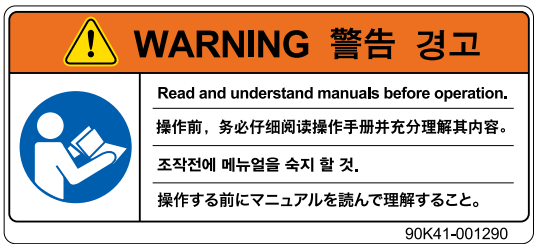
90K41-001460

■ Warning label 3 (SCARA robots, Cartesian robots, controllers*)

* Some models

WARNING

Improper installation or operation may cause serious injury.
Before installing or operating the robot, read the manual and instructions on the warning labels and understand the contents.



Instructions on this label
• Be sure to read the warning label and this manual carefully to make you completely understand the contents before attempting installation and operation of the robot. • Before starting the robot operation, even after you have read through this manual, read again the corresponding procedures and "Safety instructions" in this manual. • Never install, adjust, inspect or service the robot in any manner that does not comply with the instructions in this manual.

Potential hazard to human body	Improper installation or operation may cause serious injury.
To avoid hazard	Before installing or operating the robot, read the manual and instructions on the warning labels and understand the contents.

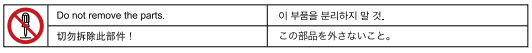
90K41-001290

■ Warning label 4 (SCARA robots*)

* This label is not attached to omnidirectional type SCARA robots.

CAUTION

Do not remove the parts on which Warning label 4 is attached.
Doing so may damage the ball screw.



Instructions on this label
The Z-axis ball screw will be damaged if the upper end mechanical stopper on the Z-axis spline is removed or moved. Never attempt to remove or move it.

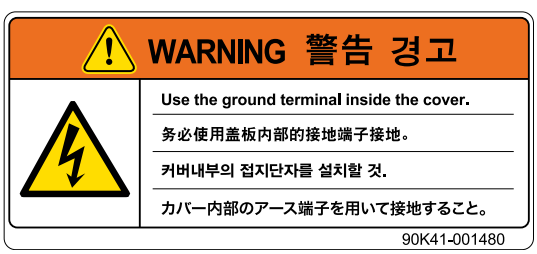
90K41-001520

■ Warning label 5 (controllers, Cartesian robots*, single-axis robots*)

* Some robot models

WARNING

Ground the controller to prevent electrical shock.
Ground terminal is located inside this cover.
Read the manual for details.



Instructions on this label
• High voltage section inside • To prevent electrical shock, be sure to ground the robot using the ground terminal.

Potential hazard to human body	Electrical shock
To avoid hazard	Ground the controller.

90K41-001480

■ Warming label 6 (controllers TS-X/TS-P)

WARNING

- **Before touching the terminals or connectors on the outside of the controller, turn off the power and wait at least 10 minutes to avoid burns or electrical shock.**
- **Motors and heatsinks become hot during and shortly after operation, so do not touch them.**

CAUTION

- **Before using the controller, be sure to read the manual thoroughly.**
- **Be sure to ground the ground terminal.**

Instructions on this label
• This indicates a high voltage is present. Touching the terminal block or connector may cause electrical shock. • This indicates the area around this symbol may become very hot. Motors and heatsinks become hot during and shortly after operation. Do not touch them to avoid burns. • This indicates important information that you must know is described in the manual. Before using the controller, be sure to read the manual thoroughly. When adding external safety circuits or connecting a power supply to the controller, read the manual carefully and make checks before beginning the work. • Be sure to ground the ground terminal to avoid electrical shock.

Potential hazard to human body	To avoid hazard
Electrical shock	Do not touch the terminal section for 10 minutes after power-off.
Do not touch them to avoid burns.	Do not touch the motors and heatsinks during power-on.
Improper installation or operation may cause serious injury.	Before installing or operating the robot, read the manual and instructions on the warning labels and understand the contents.
Electrical shock	Be sure to ground the ground terminal.

90K41-000950

■ Warming label 7 (controllers RCX240, controllers RCX340)

WARNING

These are precautions for YAMAHA and distributors' service personnel.
Customers must not attempt to open the covers.

WARNING

Wait at least 100 seconds after power-off before opening the covers.

WARNING 警告 경고
Do not open cover.
Residual voltage is present for 100 seconds after turning off the power.
切勿打开外盖。因为切断电源后，电压还将残留 100 秒。
전원을 끈후, 100초간은 잔류전압이 있으므로 커버를 열지 말 것.
電源を切った後 100 秒間は残留電圧があるのでカバーを開けないこと。
90K41-001390

Instructions on this label
• Wait at least 100 seconds after power-off before opening the covers (*). • Some parts in the controller still retain a high voltage even after power-off, so electrical shock may occur if those parts are touched.

Potential hazard to human body	Electrical shock
To avoid hazard	Wait at least 100 seconds after power-off before opening the covers (*).

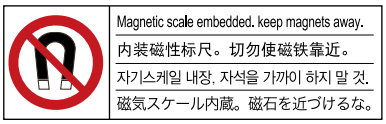
* These are precautions for YAMAHA and distributors' service personnel. Customers must not attempt to open the covers.

90K41-001390

■ Warning label 8 (single-axis linear motor robots)

CAUTION

A magnetic scale is located inside this cover. Bringing a magnet close to it may cause malfunction.

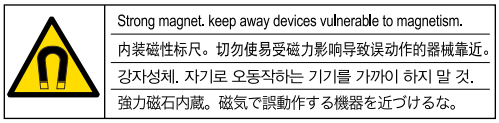
	Instructions on this label
	• To prevent the robot from operating improperly due to magnetic scale malfunction, do not bring a strong magnet to the cover. • Do not bring tools close to the magnetic scale.

90K41-001510

■ Warning label 9 (single-axis linear motor robots)

CAUTION

Powerful magnets are installed in the robot.
Do not attempt to disassemble the robot to avoid possible injury.
Do not bring any device that may malfunction due to magnetic fields close to the robot.

	Instructions on this label
	Be sure to read "6. Cautions regarding strong magnetic fields" in "Safety instructions" and make sure you fully understand its contents before handling or operating the robot.
Potential hazard to human body	Injury or death may result in some cases.
To avoid hazard	Make you understand the precautions regarding strong magnetic fields.

90K41-001500

■ Warning label 10 (Controller)*

* This label is attached to the front panel.

CAUTION

Refer to the manual.

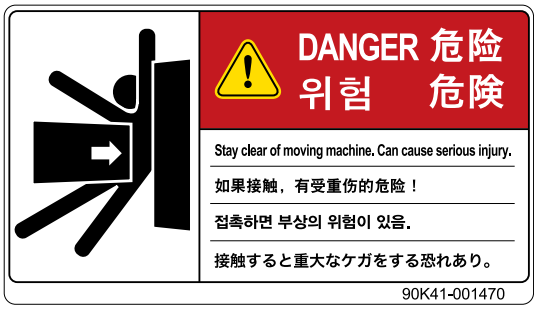
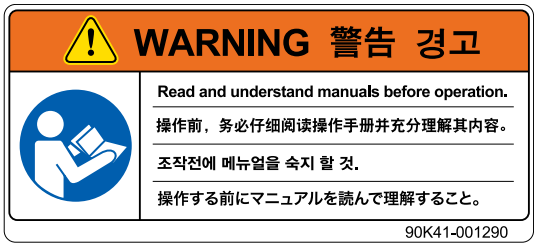
	Instructions on this label
	This indicates important information that you must know and is described in the manual. Before using the controller, be sure to read the manual thoroughly. When adding external safety circuits or connecting a power supply to the controller, read the manual carefully and make checks before beginning the work. Connectors have an orientation. Insert each connector in the correct direction.

93005-X0-00

3.1.2 Supplied warning labels

Some warning labels are not affixed to robots but included in the packing box. **These warning labels should be affixed to an easy-to-see location.**

● Warning label is attached to the robot body.
○ Warning label comes supplied with the robot and should be affixed to an easy-to-see location on the door or gate of the safety enclosure.
◎ Warning label comes supplied with the robot and should be affixed to an easy-to-see location.

		SCARA robots	Cartesian robots	Single-axis robots
Warning label 1		●*1 ○	● ○	 ○
Warning label 2		●*1	●	●*2
Warning label 3		●*1	●	◎

*1: See "Part names" in each SCARA robot manual for label positions.
*2: This label is not attached to some small single-axis robots, but is supplied with the robots.

3.2 Warning symbols

Warning symbols shown below are indicated on the robots and controllers to alert the operator to potential hazards. To use the YAMAHA robot safely and correctly always follow the instructions and cautions indicated by the symbols.

1. Electrical shock hazard symbol

WARNING

Touching the terminal block or connector may cause electrical shock, so use caution.

	Instructions by this symbol
	This indicates a high voltage is present. Touching the terminal block or connector may cause electrical shock.

93006-X0-00

2. High temperature hazard symbol

WARNING

Motors, heatsinks, and regenerative units become hot, so do not touch them.

	Instructions by this symbol
	This indicates the area around this symbol may become very hot. Motors, heatsinks, and regenerative units become hot during and shortly after operation. To avoid burns be careful not to touch those sections.

93008-X0-00

3. Caution symbol

CAUTION

Always read the manual carefully before using the controller.

	Instructions by this symbol
	This indicates important information that you must know and is described in the manual. Before using the controller, be sure to read the manual thoroughly. When adding external safety circuits or connecting a power supply to the controller, read the manual carefully and make checks before beginning the work. Connectors must be attached while facing a certain direction, so insert each connector in the correct direction.

93007-X0-00

4. Important precautions for each stage of the robot life cycle

This section describes major precautions that must be observed when using robots and controllers. Be sure to carefully read and comply with all of these precautions even if there is no alert symbol shown.

4.1 Precautions for using robots and controllers

General precautions for using robots and controllers are described below.

1. Applications where robots cannot be used

YAMAHA robots and robot controllers are designed as general-purpose industrial equipment and cannot be used for the following applications.

DANGER

YAMAHA robot controllers and robots are designed as general-purpose industrial equipment and cannot be used for the following applications.

- **In medical equipment systems which are critical to human life**
- **In systems that significantly affect society and the general public**
- **In equipment intended to carry or transport people**
- **In environments which are subject to vibration such as onboard ships and vehicles.**

2. Qualification of operators/workers

Operators or persons who perform tasks for industrial robots (such as teaching, programming, movement check, inspection, adjustment, and repair) must receive appropriate training and also have the skills needed to perform the tasks correctly and safely.
Those tasks must be performed by qualified persons who meet requirements established by local regulations and standards for industrial robots. They must also read the manual carefully and understand its contents before attempting the robot operation or maintenance.

WARNING

- **It is extremely hazardous for persons who do not have the above qualifications to perform tasks for industrial robots.**
- **Adjustment and maintenance that require removing a cover must be performed by persons who have the above qualifications. Any attempt to perform such tasks by an unqualified person may cause an accident resulting in serious injury or death.**

4.2 Essential precautions for the linear conveyor module

The linear conveyor module is a YAMAHA robot so safety measures must be followed and safety equipment must be installed just as required for other YAMAHA robots.
This section describes essential precautions for handling the linear conveyor module. Precautions for each stage in the robot life cycle are listed from the next section, so be sure to read the whole section of "Safety Instruction" in this manual.

1. Slider ejection

DANGER

The slider and workpieces ejected at high SPEED from the linear conveyor module may strike persons, causing serious and POSSIBLY fatal injuries. Please comply with the following points.

- Do not enter or allow the face and hands to intrude anywhere along the line where the linear conveyor guide rail may extend (not only ejection side of the conveyor but also the insertion side).
- If ejecting the slider on the linear conveyor, then install a suitable ejection mechanism (device to catch and stop the ejected slider).
- Install a structure and a mechanism to catch and retain the slider on the side where the slider is inserted.
- Install a safety enclosure outside the linear conveyor movement range. Design the safety enclosure so that the slider and workpieces from the linear conveyor are not ejected outside of the enclosure.

2. Preventing electrical shock

DANGER

Always comply with the instructions in this manual when installing, operating and inspecting the linear conveyor module. Failure to do so may lead to electrical shock, serious injury or even death. Please comply with the following items:

- Read and FOLLOW the instructions in this manual when grounding the linear conveyor module and installing the termination module.
- Do not touch the motor of the linear conveyor module when it is on.
- Always comply with the instructions in the manual when performing maintenance and be sure to turn off the power before starting maintenance tasks.
- If cracked or broken plastic motor parts are found, stop using the linear conveyor module immediately and turn off the power.

3. Strong magnetic field

WARNING

The linear conveyor module contains powerful permanent magnets and electromagnets that generate strong magnetic fields. Always comply with the precautions listed in this manual when using the linear conveyor module. Those persons wearing medical electronic devices such as cardiac pacemakers or hearing aids are at particular risk of major injury or even death.

- Always attach the magnet protective cover (supplied) when handling, shipping or storing the slider when removing it from the linear conveyor module's guide rails.
- Do not approach the motor of the linear conveyor module while the power is on. (Stay at least 100mm away.)
- Do not attempt to disassemble the linear conveyor module (including surrounding covers).
- Do not place any tools near the slider magnets and the linear conveyor motor while the power is on.

4. High temperature hazard

WARNING

The motor for the linear conveyor module is mounted on the module, and so it is easy to come into contact with. To allow heat generated during operation to DISSIPATE, install the module on a base made from good heat conducting material such as metal.
The motor reaches high temperatures during and IMMEDIATELY after operation, so touching it at those times may cause burns.
Before touching the motor, first turn off the controller power, then wait a while and check that the temperature has DROPPED sufficiently.

4.3 Design

4.3.1 Precautions for robots

1. Restricting the robot moving speed

WARNING

Restriction on the robot moving speed is not a safety-related function.
To reduce the risk of collision between the robot and workers, the user must take the necessary protective measures such as enable devices according to risk assessment by the user.

2. Restricting the movement range

See "7.1 Movement range" in "Safety instructions" for details on the robot's movement range.

WARNING

Soft limit function is not a safety-related function intended to protect the human body.
To restrict the robot movement range to protect the human body, use the mechanical stoppers installed in the robot (or available as options).

CAUTION

If the robot moving at high speed collides with a mechanical stopper installed in the robot (or available as option), the robot may be damaged.

3. Provide safety measures for end effector (gripper, etc.)

WARNING

- End effectors must be designed and manufactured so that they cause no hazards (such as a loose workpiece or load) even if power (electricity, air pressure, etc.) is shut off or power fluctuations occur.
- If the object gripped by the end effector might possibly fly off or drop, then provide appropriate safety protection taking into account the object size, weight, temperature, and chemical properties.

4. Provide adequate lighting

Provide enough lighting to ensure safety during work.

5. Install an operation status light

WARNING

Install a signal light (signal tower) at an easy-to-see position so that the operator will be aware of the robot stop status (temporarily stopped, emergency stop, error stop, etc.).

4.3.2 Precautions for robot controllers

1. Emergency stop input terminal

DANGER

Each robot controller has an emergency stop input terminal to trigger emergency stop. Using this terminal, install a safety circuit so that the system including the robot controller will work safely.

2. Maintain clearance

CAUTION

Do not bundle control lines or communication cables together or in close to the main power supply or power lines. Usually separate these by at least 100mm. Failure to follow this instruction may cause malfunction due to noise.

4.4 Moving and installation

4.4.1 Precautions for robots

■ Installation environment

1. Do not use in strong magnetic fields

WARNING
Do not use the robot near equipment or in locations that generate strong magnetic fields. The robot may BREAK DOWN or malfunction if used in such locations.

2. Do not use in locations subject to possible electromagnetic interference, etc.

WARNING
Do not use the robot in locations subject to electromagnetic interference, electrostatic discharge or radio frequency interference. The robot may malfunction if used in such locations creating hazardous situations.

3. Do not use in locations exposed to flammable gases

WARNING
- YAMAHA robots are not designed to be explosion-proof.
- Do not use the robots in locations exposed to explosive or inflammable gases, dust particles or liquid. Failure to follow this instruction may cause serious accidents involving injury or death, or lead to fire.

■ Moving

1. Use caution to prevent pinching or crushing of hands or fingers

WARNING
Moving parts can pinch or crush hands or fingers.
Keep hands away from the movable parts of the robot.

As instructed in Warning label 2, use caution to prevent hands or fingers from being pinched or crushed by movable parts when transporting or moving the robot. For details on warning labels, see "3. Warning labels" in "Safety instructions."

2. Take safety measures when moving robots

To ensure safety when moving a SCARA robot with an arm length of 500mm or more, use the eyebolts that come supplied with the robot. Always refer to the robot user's manual for details.
When moving other robots, please comply with the transport methods described in their respective user's manuals.

3. Take measures to prevent the robot from falling

When moving the robot by lifting it with equipment such as a hoist or crane, wear personal protective gear and be careful not to move the robot at greater than the required height.
Make sure that there are no persons on paths used for moving the robot.

WARNING
A robot falling from a high place and striking a worker may cause death or serious injury. When moving the robot, wear personal protective gear such as helmets and make sure that no one is within the surrounding area.

■ Installation

1. Protect electrical wiring and hydraulic/pneumatic hoses

Install a cover or similar item to protect the electrical wiring and hydraulic/pneumatic hoses from possible damage.

■ Wiring

1. Protective measures against electrical shock

WARNING
Always ground the robot to prevent electrical shock.

■ Adjustment

1. Adjustment that requires removing a cover

WARNING
Adjustment by removing a cover require specialized technical knowledge and skills, and may also involve hazards if attempted by an unskilled person. This adjustment must be performed only by persons who have the required qualifications described in “2. Qualification of operators/workers” in section 4.1 of this “Safety instructions”.

4.4.2 Precautions for robot controllers

■ Installation environment

1. Installation environment

WARNING
YAMAHA robots are not designed to be explosion-proof. Do not use the robots and controllers in locations exposed to explosive or inflammable gases, dust particles or liquid such as gasoline and solvents. Failure to follow this instruction may cause serious accidents involving injury or death, and lead to fire.

WARNING
- Use the robot controller in locations that support the environmental conditions specified in this manual. Operation outside the specified environmental range may cause electrical shock, fire, malfunction or product damage or deterioration.
- The robot controller and programming box must be installed at a location that is outside the robot safety enclosure yet where it is easy to operate and view robot movement.
- Install the robot controller in locations with enough space to perform work (teaching, inspection, etc.) safely. Limited space not only makes it difficult to perform work but can also cause injury.
- Install the robot controller in a stable, level location and secure it firmly. Avoid installing the controller upside down or in a tilted position.
- Provide sufficient clearance around the robot controller for good ventilation. Insufficient clearance may cause malfunction, breakdown or fire.

■ Installation

To install the robot controller, observe the installation conditions and method described in the manual.

1. Installation

WARNING
Securely tighten the screws to install the robot controller. If not securely tightened, the screws may come loose causing the controller to drop.

2. Connections

WARNING
- Always shut off all phases of the power supply externally before starting installation or wiring work. Failure to do this may cause electrical shock or product damage.
- Never directly touch conductive sections and electronic parts other than the connectors, rotary switches, and DIP switches on the outside panel of the robot controller. Touching them may cause electrical shock or breakdown.
- Securely install each cable connector into the receptacles or sockets. Poor connections may cause the controller or robot to malfunction.

■ Wiring

1. Connection to robot controller

The controller parameters are preset at the factory before shipping to match the robot model. Check the specified robot and controller combination, and connect them in the correct combination.
Since the software detects abnormal operation such as motor overloads, the controller parameters must be set correctly to match the motor type used in the robot connected to the controller.

2. Wiring safety points

WARNING

Always shut off all phases of the power supply externally before starting installation or wiring work. Failure to do this may cause electrical shock or product damage.

CAUTION

- **Make sure that no foreign matter such as cutting chips or wire scraps get into the robot controller. Malfunction, breakdown or fire may result if these penetrate inside.**
- **Do not apply excessive impacts or loads to the connectors when making cable connections. This might bend the connector pins or damage the internal PC board.**
- **When using ferrite cores for noise elimination, be sure to fit them onto the power cable as close to the robot controller and/or the robot as possible, to prevent malfunction caused by noise.**

3. Wiring method

WARNING

Securely install the connectors into the robot controller and, when wiring the connectors, make the crimp, press-contact or solder connections correctly using the tool specified by the connector manufacturer.

CAUTION

When disconnecting the cable from the robot controller, detach by gripping the connector itself and not by tugging on the cable. Loosen the screws on the connector (if fastened with the screws), and then disconnect the cable. Trying to detach by pulling on the cable itself may damage the connector or cables, and poor cable contact will cause the controller or robot to malfunction.

4. Precautions for cable routing and installation

CAUTION

- **Always store the cables connected to the robot controller in a conduit or clamp them securely in place. If the cables are not stored in a conduit or properly clamped, excessive play or movement or mistakenly pulling on the cable may damage the connector or cables, and poor cable contact will cause the controller or robot to malfunction.**
- **Do not modify the cables and do not place any heavy objects on them. Handle them carefully to avoid damage. Damaged cables may cause malfunction or electrical shock.**
- **If the cables connected to the robot controller may possibly become damaged, then protect them with a cover, etc.**
- **Check that the control lines and communication cables are routed at a gap sufficiently away from main power supply circuits and power lines, etc. Bundling them together with power lines or close to power lines may cause faulty operation due to noise.**

5. Protective measures against electrical shock

WARNING

Be sure to ground the ground terminals of the robot and controller. Poor grounding may cause electrical shock.

4.5 Safety measures

4.5.1 Safety measures

1. Referring to warning labels and manual

WARNING

- **Before starting installation or operation of the robot, be sure to read the warning labels and this manual, and comply with the instructions.**
- **Never attempt any repair, parts replacement and modification unless described in this manual. These tasks require specialized technical knowledge and skills and may also involve hazards. Please contact your distributor for advice.**

NOTE

For details on warning labels, see "3. Warning labels" in "Safety instructions."

2. Draw up "work instructions" and make the operators/workers understand them

WARNING

Decide on "work instructions" in cases where personnel must work within the robot safety enclosure to perform startup or maintenance work. Make sure the workers completely understand these "work instructions".

Decide on "work instructions" for the following items in cases where personnel must work within the robot safety enclosure to perform teaching, maintenance or inspection tasks. Make sure the workers completely understand these "work instructions".

1. Robot operating procedures needed for tasks such as startup procedures and handling switches
2. Robot speeds used during tasks such as teaching
3. Methods for workers to signal each other when two or more workers perform tasks
4. Steps that the worker should take when a problem or emergency occurs
5. Steps to take after the robot has come to a stop when the emergency stop device was triggered, including checks for cancelling the problem or error state and safety checks in order to restart the robot.
6. In cases other than above, the following actions should be taken as needed to prevent hazardous situations due to sudden or unexpected robot operation or faulty robot operation as listed below.
   - Place a display sign on the operator panel
   - Ensure the safety of workers performing tasks within the robot safety enclosure
   - Clearly specify position and posture during work
     Specify a position and posture where worker can constantly check robot movements and immediately move to avoid trouble if an error/problem occurs
   - Take noise prevention measures
   - Use methods for signaling operators of related equipment
   - Use methods to decide that an error has occurred and identify the type of error

Implement the "work instructions" according to the type of robot, installation location, and type of work task.
When drawing up the "work instructions", make an effort to include opinions from the workers involved, equipment manufacturer technicians, and workplace safety consultants, etc.

3. Take safety measures

DANGER

- **Never enter the robot movement range while the robot is operating or the main power is turned on. Failure to follow this warning may cause serious accidents involving injury or death. Install a safety enclosure or a gate interlock with an area sensor to keep all persons away from the robot movement range.**
- **When it is necessary to operate the robot while you are within the robot movement range such as for teaching or maintenance/inspection tasks, always carry the programming box with you so that you can immediately stop the robot operation in case of an abnormal or hazardous condition. Install an enable device in the external safety circuit as needed. Also set the robot moving speed to 3% or less. Failure to follow these instructions may cause serious accidents involving injury or death.**

See “7.1 Movement range” in “Safety instructions” for details on the robot’s movement range.

WARNING

- During startup or maintenance tasks, display a sign "WORK IN PROGRESS" on the programming box and operation panel in order to prevent anyone other than the person for that task from mistakenly operating the start or selector switch. If needed, take other measures such as locking the cover on the operation panel.
- Always connect the robot and robot controller in the correct combination. Using them in an incorrect combination may cause fire or breakdown.

4. Install system

When configuring an automated system using a robot, hazardous situations are more likely to occur from the automated system than the robot itself. So the system manufacturer should install the necessary safety measures required for the individual system. The system manufacturer should provide a proper manual for safe, correct operation and servicing of the system.

WARNING

To check the robot controller operating status, refer to this manual and to related manuals. Design and install the system including the robot controller so that it will always work safely.

5. Precautions for operation

WARNING

- Do not touch any electrical terminal. Directly touching these terminals may cause electrical shock, equipment damage, and malfunction.
- Do not touch or operate the robot controller or programming box with wet hands. Touching or operating them with wet hands may result in electrical shock or breakdown.

6. Do not disassemble and modify

WARNING

Never disassemble and modify any part in the robot, controller, and programming box. Do not open any cover. Doing so may cause electrical shock, breakdown, malfunction, injury, or fire.

4.5.2 Installing a safety enclosure

Be sure to install a safety enclosure to keep anyone from entering within the movement range of the robot. The safety enclosure will prevent the operator and other persons from coming in contact with moving parts of the robot and suffering injury.
See “7.1 Movement range” in “Safety instructions” for details on the robot’s movement range.

DANGER

Serious injury may result from contact with a moving robot.

- Keep outside of the robot safety enclosure during operation.
- Press the emergency stop button before entering the safety enclosure.

WARNING

- Install an interlock that triggers emergency stop when the door or gate of the safety enclosure is opened.
- The safety enclosure should be designed so that no one can enter inside except from the door or gate equipped with an interlock device.
- Warning label 1 (See "3. Warning labels" in "Safety instructions") that comes supplied with a robot should be affixed to an easy-to-see location on the door or gate of the safety enclosure.

4.6 Operation

When operating a robot, ignoring safety measures and checks may lead to serious accidents. Always take the following safety measures and checks to ensure safe operation.

DANGER

Check the following points before starting robot operation.

- **No one is within the robot safety enclosure.**
- **The programming unit is in the specified location.**
- **The robot and peripheral equipment are in good condition.**

4.6.1 Trial operation

After installing, adjusting, inspecting, maintaining or repairing the robot, perform trial operation using the following procedures.

1. If a safety enclosure has not yet been provided right after installing the robot:

Then rope off or chain off the movement range around the robot in place of the safety enclosure and observe the following points.
See “7.1 Movement range” in “Safety instructions” for details on the robot’s movement range.

DANGER

Place a "Robot is moving - KEEP AWAY!" sign to keep the operator or other personnel from entering within the movement range of the robot.

WARNING

- **Use sturdy, stable posts which will not fall over easily.**
- **The rope or chain should be easily visible to everyone around the robot.**

2. Check the following points before turning on the controller.

- Is the robot securely and correctly installed?
- Are the electrical connections to the robot wired correctly?
- Are items such as air pressure correctly supplied?
- Is the robot correctly connected to peripheral equipment?
- Have safety measures (safety enclosure, etc.) been taken?
- Does the installation environment meet the specified standards?

3. After the controller is turned on, check the following points from outside the safety enclosure.

- Does the robot start, stop and enter the selected operation mode as intended?
- Does each axis move as intended within the soft limits?
- Does the end effector move as intended?
- Are the correct signals being sent to the end effector and peripheral equipment?
- Does emergency stop function?
- Are teaching and playback functions normal?
- Are the safety enclosure and interlocks functioning as intended?

4. Working inside safety enclosures

Before starting work within the safety enclosure, **always confirm from outside the enclosure that each protective function is operating correctly (see the previous section 2.3).**

DANGER

Never enter within the movement range while within the safety enclosure.

See “7.1 Movement range” in “Safety instructions” for details on the robot’s movement range.

WARNING

When work is required within the safety enclosure, place a sign "Work in progress" in order to keep other persons from operating the controller switch or operation panel.

WARNING

When work within the safety enclosure is required, always turn off the controller power except for the following cases:

Exception

Work with power turned on, but robot in emergency stop

Origin position setting	**SCARA robots**	Follow the precautions and procedure described in "Adjusting the origin".
Standard coordinate setting	**SCARA robots**	Follow the precautions and procedure described in "Setting the standard coordinates".
Soft limit settings	**SCARA robots**	Follow the precautions and procedure described in "Setting the soft limits".
	Cartesian robots **Single-axis robots**	Follow the precautions and procedure described in "Soft limit" in each controller manual.

Work with power turned on

Teaching	**SCARA robots** **Cartesian robots** **Single-axis robots**	Refer to "5. Teaching within safety enclosure" described below.

5. Teaching within the safety enclosure

When performing teaching within the safety enclosure, check or perform the following points **from outside the safety enclosure**.

DANGER

Never enter within the movement range while within the safety enclosure.

See “7.1 Movement range” in “Safety instructions” for details on the robot’s movement range.

WARNING

- **Make a visual check to ensure that no hazards are present within the safety enclosure.**
- **Check that the programming box or handy terminal operates correctly.**
- **Check that no failures are found in the robot.**
- **Check that emergency stop works correctly.**
- **Select teaching mode and disable automatic operation.**

4.6.2 Automatic operation

Check the following points when operating the robot in AUTO mode. Observe the instructions below in cases where an error occurs during automatic operation. Automatic operation described here includes all operations in AUTO mode.

1. Checkpoints before starting automatic operation

Check the following points before starting automatic operation

DANGER

- **Check that no one is within the safety enclosure.**
- **Check the safety enclosure is securely installed with interlocks functional.**

WARNING

- **Check that the programming box / handy terminal and tools are in their specified locations.**
- **Check that the signal tower lamps or other alarm displays installed for the system are not lit or flashing, indicating no error is occurring on the robot and peripheral devices.**

2. During automatic operation and when errors occur

After automatic operation starts, check the operation status and the signal tower to ensure that the robot is in automatic operation.

DANGER

Never enter the safety enclosure during automatic operation.

WARNING

If an error occurs in the robot or peripheral equipment, observe the following procedure before entering the safety enclosure.

1) Press the emergency stop button to set the robot to emergency stop.

2) Place a sign on the start switch, indicating that the robot is being inspected in order to keep other persons from restarting the robot.

4.6.3 Precautions during operation

1. When the robot is damaged or an abnormal condition occurs

WARNING

- **If unusual odors, noise or smoke occur during operation, immediately turn off power to prevent possible electrical shock, fire or breakdown. Stop using the robot and contact your distributor.**
- **If any of the following damage or abnormal conditions occurs the robot, then continuing to operate the robot is dangerous. Immediately stop using the robot and contact your distributor.**

Damage or abnormal condition	Type of danger
Damage to machine harness or robot cable	Electrical shock, robot malfunction
Damage to robot exterior	Damaged parts fly off during robot operation
Abnormal robot operation (position deviation, vibration, etc.)	Robot malfunction
Z-axis (vertical axis) or brake malfunction	Z-axis unit falls off

2. High temperature hazard

WARNING

- **Do not touch the robot controller and robot during operation. The robot controller and robot body are very hot during operation, so burns may occur if these sections are touched.**
- **The motor and speed reduction gear casing are very hot shortly after operation, so burns may occur if these are touched. Before touching those parts for inspections or servicing, turn off the controller, wait for a while and check that their temperature has cooled.**

3. Use caution when releasing the Z-axis (vertical axis) brake

WARNING

The vertical axis will slide downward when the brake is released, causing a hazardous situation. Take adequate safety measures in consideration by taking the weight and shape into account.

- Before releasing the brake after pressing the emergency stop button, place a support under the vertical axis so that it will not slide down.
- Be careful not to let your body get caught between the vertical axis and the installation base when performing tasks (direct teaching, etc.) with the brake released.

4. Be careful of Z-axis movement when the controller is turned off or emergency stop is triggered (air-driven Z-axis)

WARNING

The Z-axis starts moving upward when power to the controller or PLC is turned off, the program is reset, emergency stop is triggered, or air is supplied to the solenoid valve for the Z-axis air cylinder.

- Do not let hands or fingers get caught and squeezed by robot parts moving along the Z-axis.
- Keep the usual robot position in mind so as to prevent the Z-axis from hanging up or binding on obstacles during raising of the Z-axis except in case of emergency stop.

5. Take protective measures when the Z-axis interferes with peripheral equipment (air-driven Z-axis)

WARNING

When the Z-axis comes to a stop due to obstruction from peripheral equipment, the Z-axis may move suddenly after the obstruction is removed, causing injury such as pinched or crushed hands.

- Turn off the controller and reduce the air pressure before attempting to remove the obstruction.
- Before reducing the air pressure, place a support under the Z-axis because the Z-axis will drop under its own weight.

6. Be careful of Z-axis movement when air supply is stopped (air-driven Z-axis)

WARNING

The Z-axis will slide downward when the air pressure to the Z-axis air cylinder solenoid valve is reduced, creating a hazardous situation.
Turn off the controller and place a support under the Z-axis before cutting off the air supply.

7. Make correct parameter settings

CAUTION

The robot must be operated with the correct tolerable moment of inertia and acceleration coefficients that match the manipulator tip mass and moment of inertia. Failure to follow this instruction will lead to a premature end to the drive unit service life, damage to robot parts, or cause residual vibration during positioning.

8. If the X-axis, Y-axis or R-axis rotation angle is small

CAUTION

If the X-axis, Y-axis or R-axis rotation angle is set smaller than 5 degrees, then it will always move within the same position. This restricted position makes it difficult for an oil film to form on the joint support bearing, and so may possibly damage the bearing. In this type of operation, add a range of motion so that the joint moves through 90 degrees or more, about 5 times a day.

4.7 Inspection and maintenance

Always perform daily and periodic inspections and make a pre-operation check to ensure there are no problems with the robot and related equipment. If a problem or abnormality is found, then promptly repair it or take other measures as necessary.
Keep a record of periodic inspections or repairs and store this record for at least 3 years.

4.7.1 Before inspection and maintenance work

1. Do not attempt any work or operation unless described in this manual.

Never attempt any work or operation unless described in this manual.
If an abnormal condition occurs, please be sure to contact your distributor. Our service personnel will take appropriate action.

WARNING

Never attempt inspection, maintenance, repair, and part replacement unless described in this manual. These tasks require specialized technical knowledge and skills and may also involve hazards. Please be sure to contact your distributor for advice.

2. Precautions during repair and parts replacement

WARNING

When it is necessary to repair or replace parts of the robot or controller, please be sure to contact your distributor and follow the instructions they provide. Inspection and maintenance of the robot or controller by an unskilled, untrained person is extremely hazardous.

Adjustment, maintenance and parts replacement require specialized technical knowledge and skills, and also may involve hazards. These tasks must be performed only by persons who have enough ability and qualifications required by local laws and regulations.

WARNING

Adjustment and maintenance by removing a cover require specialized technical knowledge and skills, and may also involve hazards if attempted by an unskilled person. This adjustment must be performed only by persons who have the required qualifications described in "2. Qualification of operators/workers" in section 4.1 of this "Safety instructions".

3. Shut off all phases of power supply

WARNING

Always shut off all phases of the power supply externally before cleaning the robot and controller or securely tightening the terminal screws etc. Failure to do this may cause electrical shock or product damage or malfunction.

4. Allow a waiting time after power is shut off (Allow time for temperature and voltage to drop)

WARNING

- **When performing maintenance or inspection of the robot controller under your distributor's instructions, wait at least the time (*) specified for each controller after turning the power off. Some components in the robot controller are very hot or still retain a high voltage shortly after operation, so burns or electrical shock may occur if those parts are touched.**
- **The motor and speed reduction gear casing are very hot shortly after operation, so burns may occur if they are touched. Before touching those parts for inspections or servicing, turn off the controller, wait for a while and check that the temperature has cooled.**

* For information on how long you should wait after turning the power off, see the user's manual for each controller.

5. Precautions during inspection of controller

WARNING

- **When you need to touch the terminals or connectors on the outside of the controller during inspection, always first turn off the controller power switch and also the power source in order to prevent possible electrical shock.**
- **Do not disassemble the controller. Never touch any internal parts of the controller. Doing so may cause breakdown, malfunction, injury, or fire.**

4.7.2 Precautions during service work

1. Precautions when removing a motor (Cartesian robots and vertical mount single-axis robots)

WARNING

The vertical axis will slide down when the motor is removed, causing a hazardous situation.

- Turn off the controller and place a support under the vertical axis before removing the motor.
- Be careful not to let your body get caught by the driving unit of the vertical axis or between the vertical axis and the installation base.

2. Be careful when removing the Z-axis motor (SCARA robots)

WARNING

The Z-axis will slide downward when the Z-axis motor is removed, causing a hazardous situation.

- Turn off the controller and Place a support under the Z-axis before removing the Z-axis motor.
- Be careful not to let your body get caught by the driving unit of the Z-axis or between the Z-axis drive unit and the installation base.

3. Do not remove the Z-axis upper limit mechanical stopper

CAUTION

Warning label 4 is attached to each SCARA robot. (For details on warning labels, see "3. Warning labels" in "Safety instructions.")

Removing the upper limit mechanical stopper installed to the Z-axis spline or shifting its position will damage the Z-axis ball screw. Never attempt to remove it.

4. Use caution when handling a robot that contains powerful magnets

WARNING

Powerful magnets are installed inside the robot. Do not disassemble the robot since this may cause injury.

Devices that may malfunction due to magnetic fields must be kept away from this robot.

See "6. Cautions regarding strong magnetic fields" in "Safety instructions" for detailed information on strong magnetic fields.

5. Use the following caution items when disassembling or replacing the pneumatic equipment.

WARNING

Air or parts may fly outward if pneumatic equipment is disassembled or parts replaced while air is still supplied.

- Do service work after turning off the controller, reducing the air pressure, and exhausting the residual air from the pneumatic equipment.
- Before reducing the air pressure, place a support stand under the Z-axis (2-axis robots with air driven Z-axis) since it will drop under its own weight.

6. Use caution to avoid contact with the controller cooling fan

WARNING

- Touching the rotating fan may cause injury.
- If removing the fan cover, first turn off the controller and make sure the fan has stopped.

7. Precautions for robot controllers

CAUTION

- Back up the robot controller internal data on an external storage device. The robot controller internal data (programs, point data, etc.) may be lost or deleted for unexpected reasons. Always make a backup of this data.
- Do not use thinner, benzene, or alcohol to wipe off the surface of the programming box. The surface sheet may be damaged or printed letters or marks erased. Use a soft, dry cloth and gently wipe the surface.
- Do not use a hard or pointed object to press the keys on the programming box. Malfunction or breakdown may result if the keys are damaged. Use your fingers to operate the keys.

4.8 Disposal

When disposing of robots and related items, handle them carefully as industrial wastes. Use the correct disposal method in compliance with your local regulations, or entrust disposal to a licensed industrial waste disposal company.

1. Disposal of lithium batteries

When disposing of lithium batteries, use the correct disposal method in compliance with your local regulations, or entrust disposal to a licensed industrial waste disposal company. We do not collect and dispose of the used batteries.

2. Disposal of packing boxes and materials

When disposing of packing boxes and materials, use the correct disposal method in compliance with your local regulations. We do not collect and dispose of the used packing boxes and materials.

3. Strong magnet

WARNING

Strong magnets are installed in the robot. Be careful when disposing of the robot.

See "6. Cautions regarding strong magnetic fields" in "Safety instructions" for detailed information on strong magnetic fields.

5. Emergency action when a person is caught by robot

If a person should get caught between the robot and a mechanical part such as the installation base, then release the axis.

■ Emergency action

Release the axis while referring to the following section in the manual for the robot controller.

Controller	Refer to:
RCX240	Section 1, "Freeing a person caught by the robot" in Chapter 1
RCX340	Section 1, "Emergency action when a person is caught by robot" in Chapter 1

NOTE

Make a printout of the relevant page in the manual and post it a conspicuous location near the controller.

6. Cautions regarding strong magnetic fields

Some YAMAHA robots contain parts generating strong magnetic fields which may cause bodily injury, death, or device malfunction. Always comply with the following instructions.

- Persons wearing medical electronic devices such as cardiac pacemakers or hearing aids must keep away from the linear single-axis robot and linear conveyor. (Stay at least 100mm away.)
- Persons wearing ID cards, purses, and/or wristwatches must keep away from the linear single-axis robot and linear conveyor.
- Do not attempt to disassemble the linear single-axis robot and linear conveyor (including surrounding covers).
- Do not bring tools close to the internal parts of the robot and the linear conveyor magnets.
- Always attach the magnet protective cover (supplied) when handling, shipping or storing the linear conveyor's slider when removing it from the module.

7. Using the robot safely

7.1 Movement range

When a tool or workpiece is attached to the robot manipulator tip, the actual movement range enlarges from the movement range of the robot itself (Figure A) to include the areas taken up by movement of the tool and workpiece attached to the manipulator tip (Figure B).
The actual movement range expands even further if the tool or workpiece is offset from the manipulator tip.
The movement range here is defined as the range of robot motion including all areas through which the robot arms, the tool and workpiece attached to the manipulator tip, and the solenoid valves attached to the robot arms move.
To make the robot motion easier to understand, the figures below only show the movement ranges of the tool attachment section, tool, and workpiece.
Please note that during actual operation, the movement range includes all areas where the robot arms and any other parts move along with the robot.

Movement range

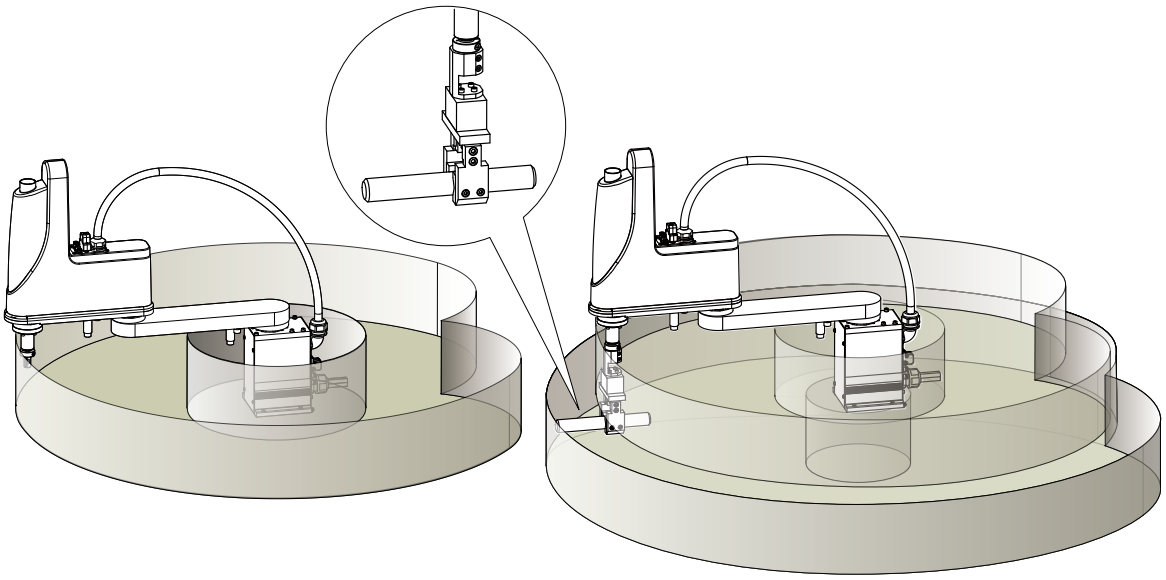


Figure A: Movement range of robot itself

Figure B: Movement range when tool and workpiece are attached to manipulator tip

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CAUTION

To make the robot motion easier to understand, the above figures only show the movement ranges of the tool attachment section, tool, and workpiece. In actual operation, the movement range includes all areas where the robot arms and any other parts move along with the robot.

7.2 Robot protective functions

Protective functions for YAMAHA robots are described below.

1. Overload detection

This function detects an overload applied to the motor and turns off the servo.
If an overload error occurs, take the following measures to avoid such errors:

1. Insert a timer in the program.
2. Reduce the acceleration.

2. Overheat detection

This function detects an abnormal temperature rise in the driver inside the controller and turns off the servo.
If an overheat error occurs, take the following measures to avoid the error:

1. Insert a timer in the program.
2. Reduce the acceleration.

3. Soft limits

Soft limits can be set on each axis to limit the working envelope in manual operation after return-to-origin and during automatic operation. The working envelope is the area limited by soft limits.

WARNING

Soft limit function is not a safety-related function intended to protect the human body.
To restrict the robot movement range to protect the human body, use the mechanical stoppers installed in the robot (or available as options).

4. Mechanical stoppers

If the servo is turned off by emergency stop operation or protective function while the robot is moving, then these mechanical stoppers prevent the axis from exceeding the movement range. The movement range is the area limited by the mechanical stoppers.

SCARA robots	• The X and Y axes have mechanical stoppers that are installed at both ends of the maximum movement range. Some robot models have a standard feature that allows changing the mechanical stopper positions. On some other models, the mechanical stopper positions can also be changed by using option parts. • The Z-axis has a mechanical stopper at the upper end and lower end. The stopper positions can be changed by using option parts. • No mechanical stopper is provided on the R-axis.
Single-axis robots **Cartesian robots**	• The linear movement axis has a mechanical stopper at both ends of the maximum movement range. The positions of these mechanical stoppers cannot be changed. • No mechanical stopper is provided on the rotational axis.

WARNING

Axis movement does not stop immediately after the servo is turned off by emergency stop or other protective functions, so use caution.

CAUTION

If the robot moving at high speed collides with a mechanical stopper installed in the robot (or available as option), the robot may be damaged.

DANGER

When the linear conveyor module is used to insert or eject the slider, mechanical stoppers cannot be attached to the module body due to the structural limits. So install a device to catch and stop the slider being ejected at high speed from the module, as well as other necessary safety measures.

5. Z-axis (vertical axis) brake

An electromagnetic brake is installed on the Z-axis to prevent the Z-axis from sliding downward when the servo is OFF. This brake is working when the controller is OFF or the Z-axis servo power is OFF even when the controller is ON. The Z-axis brake can be released by the programming unit / handy terminal or by a command in the program when the controller is ON.

WARNING

The vertical axis will slide downward when the brake is released, causing a hazardous situation. Take adequate safety measures in consideration by taking the weight and shape into account.

- **Before releasing the brake after pressing the emergency stop button, place a support under the vertical axis so that it will not slide down.**
- **Be careful not to let your body get caught between the vertical axis and the installation base when performing tasks (direct teaching, etc.) with the brake released.**

7.3 Residual risk

To ensure safe and correct use of YAMAHA robots and controllers, System integrators and/or end users implement machinery safety design that conforms to ISO12100.
Residual risks for YAMAHA robots and controllers are described in the DANGER or WARNING instructions provided in each chapter and section. Read them carefully.

7.4 Special training for industrial robot operation

Operators or persons who handle the robot for tasks such as for teaching, programming, movement checks, inspections, adjustments, and repairs must receive appropriate training and also have the skills needed to perform the job correctly and safely. They must also read the manual carefully to understand its contents before attempting the robot operation or maintenance.

Tasks related to industrial robots (teaching, programming, movement check, inspection, adjustment, repair, etc.) must be performed by qualified persons who meet requirements established by local regulations and safety standards for industrial robots.

Comparison of terms used in this manual with ISO

This manual	ISO 10218-1	Note
Maximum movement range	maximum space	Area limited by mechanical stoppers.
Movement range	restricted space	Area limited by movable mechanical stoppers.
Working envelope	operational space	Area limited by software limits.
Within safety enclosure	safeguarded space	

See “7.1 Movement range” in “Safety instructions” for details on the robot’s movement range.

Revision record

Manual version	Issue date	Description
Ver. 1.00	May 2012	First edition
Ver. 1.01	Jun. 2012	Description of "Emergency action when a person is caught by robot" was added, the work sequence for working within the safety enclosure changed, typing errors corrected, etc.
Ver. 1.02	Sep. 2012	Description of warning labels was added; descriptions of "soft limits", "mechanical stoppers" and work performed with vertical axis brake released were changed; and residual risk description was added.
Ver. 1.03	Dec. 2012	Warning on restricting the robot moving speed was added and description of warning label language was changed.
Ver. 1.04	Jun. 2013	Description of “Movement range” was added.
Ver. 1.05	Sep. 2013	Description of linear conveyor module was added.
Ver. 1.06	Apr. 2014	Description of warning labels was added and description of “Qualification of operators/workers” was changed, etc.

YAMAHA Safety Instructions

Apr. 2014
Ver. 1.06
This manual is based on Ver. 1.06 of Japanese manual.

YAMAHA MOTOR CO., LTD. IM Operations

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Chapter 1 Measures for each country's safety standards

Contents

1. Overview 1-1

2. Safety standards 1-2

2.1 Measures for CE marking 1-2

2.1.1 Cautions regarding compliance with EC Directives 1-2
2.1.2 CE marking 1-2
2.1.3 Applicable EC Directives and their related standards 1-3
2.1.4 Robots subject to CE Marking 1-3
2.1.5 Cautions regarding the official language of EU countries 1-3

2.2 Measures for KCs 1-4

2.2.1 Cautions regarding compliance with KCs 1-4
2.2.2 KCs mark 1-4
2.2.3 Normative standards 1-4
2.2.4 Robots subject to KCs 1-5

3. Usage conditions 1-6

1. Overview

This section provides a basic description of how the RCX series/SR1 series controllers comply with the safety standards of each country.
The following shows the basic differences among the controllers with CE specifications, KCs specifications that comply with the safety standards and normal specifications.

■ Differences in main specifications (RCX340 controller)

	CE specifications	Normal specifications
AUTO/MANUAL mode input	Provided	Not provided
Programming box	PBX-E with enable switch	PBX without enable switch

■ Differences in main specifications (RCX240 controller)

	CE specifications and KCs specifications	Normal specifications
Service mode	Provided	Not provided
Programming box	RPB-E with enable switch	RPB without enable switch

■ Differences in main specifications (RCX221/RCX222 controller)

	CE specifications	Normal specifications
Service mode	Provided	Not provided
Programming box	RPB-E with enable switch	RPB without enable switch

■ Differences in main specifications (SR1 series controller)

	CE specifications	Normal specifications
Service mode	Provided	Not provided
Programming box	HPB-D with enable switch	HPB without enable switch

2. Safety standards

2.1 Measures for CE marking

2.1.1 Cautions regarding compliance with EC Directives

The YAMAHA robot (robot and controller) is not, in itself, a robot system. The YAMAHA robot is just one component that is incorporated into the customer's system (built-in equipment), and we declare that YAMAHA robots conform to the EC Directives only within the scope of built-in equipment. This does not therefore guarantee that YAMAHA robots conform to EC Directives in cases where the robot is used independently. Customers who incorporate a YAMAHA robot into their final system which will be shipped to, or used, in the EU, should therefore verify that the overall system is compliant with EC Directives.

● Differences between YAMAHA robots (robot and controller) and robot systems

A YAMAHA robot (robot and controller) is just one component in a robot system, and is not, in itself, a robot system.
This is because a YAMAHA robot does not include the "end effector(s)" or "any equipment, devices, or sensors required for the robot to perform its tasks", as defined in "Industrial Robot system" of the ISO 10218-1: 2011 Standard - Clause 3.11.

2.1.2 CE marking

YAMAHA robots are components that are incorporated into the customer's system (built-in equipment). We therefore declare regarding EC Directives that YAMAHA robots are "Partly completed machinery" and so we do not affix a CE mark to the robots.

2.1.3 Applicable EC Directives and their related standards

The tables below show directives and related standards applied to YAMAHA robots.

■ RCX240/RCX340

EC Directive	Related Standards
Machinery Directive 2006/42/EC	EN ISO12100 : Safety of machinery – General principles for design – Risk assessment and risk reduction EN ISO10218-1 : Robots and robotic devices – Safety requirements for industrial robots – Part 1: Robots EN 60204-1 : Safety of machinery – Electrical equipment of machines – Part 1: General requirements
EMC Directive 2004/108/EC	EN 55011 : Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement EN 61000-6-2 : Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments

■ RCX221/RCX222/SR1

EC Directive	Related Standards
Machinery Directive 2006/42/EC	EN ISO12100 : Safety of machinery – General principles for design – Risk assessment and risk reduction EN 60204-1 : Safety of machinery – Electrical equipment of machines – Part 1: General requirements
EMC Directive 2004/108/EC	EN 55011 : Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement EN 61000-6-2 : Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments

2.1.4 Robots subject to CE Marking

The following robot series products are subject to CE marking.

Controller	Robot Name
RCX340 RCX240	Single-axis robots : FLIP-X series, PHASER series Cartesian type robots : XY-X series Pick-and-place type robots : YP-X series SCARA type robots : YK-X series, YK-XG series, YK-XR series, YK-TW series
RCX221 RCX222	Single-axis robots : FLIP-X series, PHASER series Cartesian type robots : XY-X series Pick-and-place type robots : YP-X series
SR1	Single-axis robots : FLIP-X series, PHASER series

2.1.5 Cautions regarding the official language of EU countries

For equipment that will be installed in EU countries, the language used for the manuals, warning labels, operation screen characters, and CE declarations is English only.
Warning labels only have pictograms or else include warning messages in English. In the latter case, messages in Japanese or other languages might be added.

2.2 Measures for KCs

KCs is a system that conforms to Occupational Safety and Health Act and Report of Declaration of Conformity of hazardous machines and devices.
For machines specified in this system, the KCs mark needs to be indicated by conducting the forced certification or Report of Declaration of Conformity. Industrial robots that have manipulators with 3 or more axes are specified as machines needing the Report of Declaration of Conformity in South Korea's Ministry of Employment and Labor Notification No. 1201-46.
Its safety standards are defined in separate table 2 of this notification.

This section describes basic items necessary to make the RCX240 series compliant with KCs.

2.2.1 Cautions regarding compliance with KCs

The YAMAHA robot series is one component that is incorporated into the customer's system (built-in equipment). The Report of Declaration of Conformity is performed based on the preconditions that additional safety measures are taken for the customer's system.
For the contents of the safety measures, refer to Chapter 2.
This does not therefore guarantee that YAMAHA robots conform to KCs in cases where the robot is used independently.
Customers who incorporate a YAMAHA robot into their final system which will be shipped to, or used, in Korea, should therefore verify that the overall system is compliant with KCs.

2.2.2 KCs mark

For robots and controllers that apply to the KCs mark, the Report of Declaration of Conformity is submitted to Korean Occupational Safety and Health Agency (KOSHA) and the KCs mark is affixed to robot controllers.

2.2.3 Normative standards

- Electromagnetic Compatibility (EMC)
- Industrial robot manufacture and safety standards

2.2.4 Robots subject to KCs

The following robot series products are subject to the KCs mark.

As of June, 2014

Product	Type	Model name	
Controller	Program	RCX240(S)	KCs specifications
Cartesian robots	Arm type	FXYx	3 axes
		SXYx	3 axes
			4 axes
		SXYBx	3 axes
			4 axes
		MXYx	3 axes
			4 axes
		HXYx	3 axes
			4 axes
	Gantry type	MXYx	3 axes
			4 axes
		HXYx	3 axes
			4 axes
	Moving arm type	SXYx	3 axes
		MXYx	3 axes
		HXYx	3 axes
	Pole type	MXYx	3 axes
		HXYx	3 axes
SCARA robots	Standard type	YK250XG, YK350XG, YK400XG YK500XGL, YK600XGL, YK500XG, YK600XG, YK600XGH, YK700XG, YK800XG, YK900XG, YK1000XG	
	Clean type	YK250XGC, YK350XGC, YK400XGC, YK500XGLC, YK600XGLC	
	Wall-mount type	YK500XGS, YK600XGS, YK700XGS, YK800XGS, YK900XGS, YK1000XGS	
	Dust-proof & drip-proof type	YK250XGP, YK350XGP, YK400XGP, YK500XGLP, YK600XGLP	
	Orbit type	YK500TW	

Robot products may not be applicable to KCs depending on their uses, operating conditions, or environments. For details, contact your distributor before purchasing a product.

CAUTION

The robots shown below are subject to the KCs mark. However, as the Report of Declaration of Conformity has not been made, these robots cannot be used in Korea.
Additionally, special order robots are also not applicable to the KCs mark. For details, contact your distributor.

Cartesian robots	NXY, SXYxC
SCARA robots	YK-X series all models
	YK120XG, YK150XG, YK180XG
	YK300XGS, YK400XGS
	YK500XGP to YK1000XGP
	YK400XR (Planned to declare in the second half of 2014.)
Pick-and-place type robots	YP-X series
Robot controllers	RCX340 series (Planned to declare in the second half of 2014.)

3. Usage conditions

The following description gives major operating conditions for YAMAHA robot series products.

● EMC (Electromagnetic compatibility)

YAMAHA robot series products are designed for use in industrial environments.
(Applicable definition relating to the EMC Directive: Refer to the EN61000-6-2 (IEC61000-6-2) Standard, Clause 1 "Scope".)

In order to conform to the EMC Directive, the customer must evaluate the finished product (entire system) and take necessary countermeasures. Refer to EMC countermeasures for single units of YAMAHA robots, which are described in the next chapter in this manual.

● Installation conditions

- **Protective structure**

  YAMAHA robots are classified as built-in equipment and have a **"Class I" protective structure against electrical shock**.

  The robot and controller must therefore be grounded properly to prevent possible electrical shock. For details, refer to the controller user's manual and the robot user's manual.

- **Enclosure**

  The robot controller case is not designed as an enclosure that conforms to the EN60204-1 (IEC60204-1) Standard. Suitable protection should therefore be provided to prevent the danger of electrical shock due to inadvertent contact and ambient environment problems (dust, water, etc.).

- **Insulation co-ordination**

  Regarding insulation co-ordination, YAMAHA robots and controllers are designed to meet the following conditions:

  Overvoltage category II (RCX340 is applicable to overvoltage category III.)
  Pollution degree 2

  Take proper countermeasures as needed if the robot or controller is used in environments more severe than these levels.

● Explosion-proof

- **YAMAHA robots and robot controllers are not designed to meet explosion-proof specifications.**

  Do not use them in environments exposed to flammable gases, gasoline, or solvents which could cause explosion or fire.

Chapter 2 RCX series

Contents

1. System overview 2-1

1.1 System overview 2-1

1.1.1 Main system configuration 2-1

1.2 Control system configuration 2-4

1.2.1 Basic configuration 2-4

1.2.2 Power supply and emergency stop system circuit configuration 2-8

1.3 Programming box 2-9

1.3.1 PBX-E 2-9

1.3.1.1 Part names and functions 2-9

1.3.1.2 PB connector 2-10

1.3.2 RPB-E 2-11

1.3.2.1 Part names and functions 2-11

1.3.2.2 RPB connector 2-12

1.4 CE specifications and KCs specifications 2-14

1.4.1 Manual mode (Applicable controller: RCX340) 2-14

1.4.1.1 MANUAL mode parameter settings 2-15

1.4.2 SERVICE mode (Applicable controller: RCX240/221/222/SR1) 2-16

1.4.2.1 Flow for enabling the SERVICE mode functions 2-17

1.4.2.2 SERVICE mode parameter settings 2-17

2. EMC countermeasure examples 2-19

2.1 RCX340 2-19

2.1.1 Configuration 2-19

2.1.2 Countermeasure components 2-20

2.2 RCX240 2-22

2.2.1 Configuration 2-22

2.2.2 Countermeasure components 2-23

2.3 RCX221/RCX222 2-26

2.3.1 Configuration 2-26

2.3.2 Countermeasure components 2-27

3. External safety circuit examples 2-30

3.1 Safety requirements 2-30

3.1.1 CE marking 2-30

3.1.2 KCs mark 2-30

3.2 Circuit examples for the RCX340 2-31

3.2.1 Category 3 2-31

3.2.2 Overview of circuit operation 2-32

3.3 Circuit examples for the RCX240 2-33

3.3.1 Category 3 2-33

3.3.2 Overview of circuit operation 2-34

3.4 Circuit examples for the RCX221/RCX222 2-35

3.4.1 Category 4 2-37
3.4.2 Category 3 2-38
3.4.3 Category 2 2-39
3.4.4 Overview of circuit operation 2-40

1. System overview

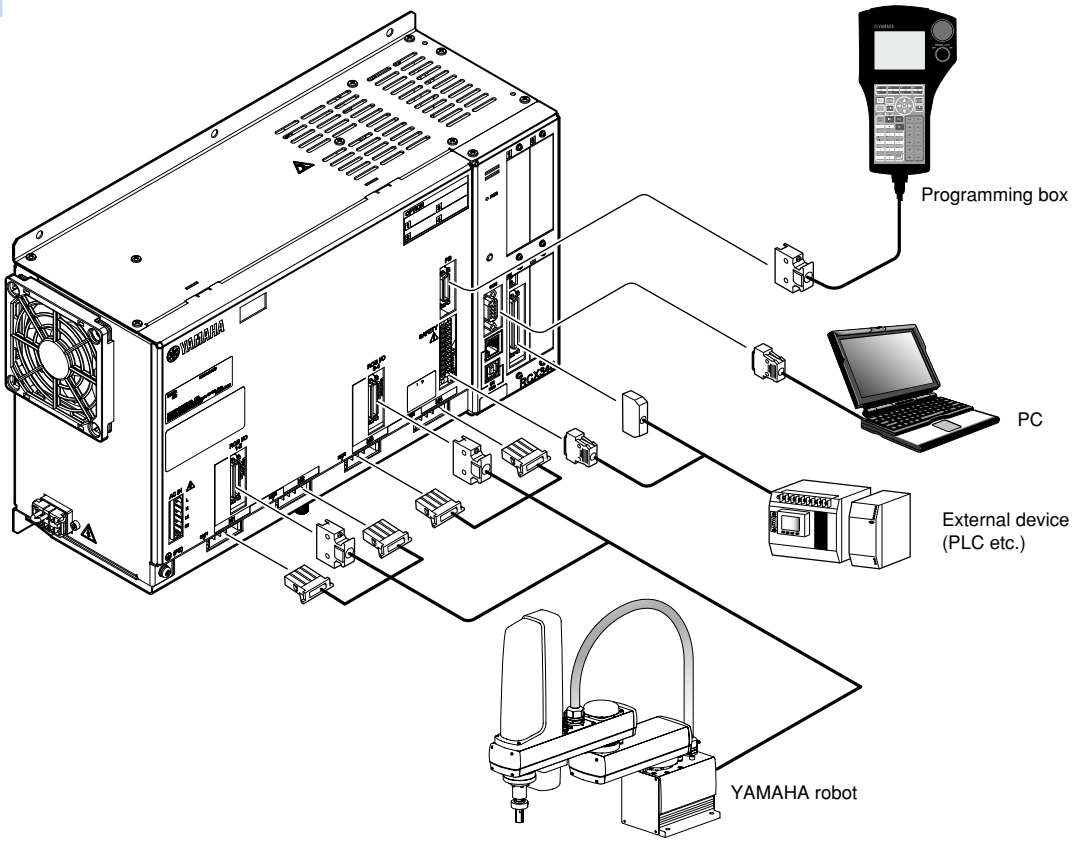
1.1 System overview

The RCX series controllers are designed for use with a SCARA robot or Cartesian robot, mainly for assembly and pick-and-place applications. Applications also include various inspection instruments, sealers and spray equipment utilizing linear and circular interpolation.

1.1.1 Main system configuration

■ **RCX340**

System for controlling one robot



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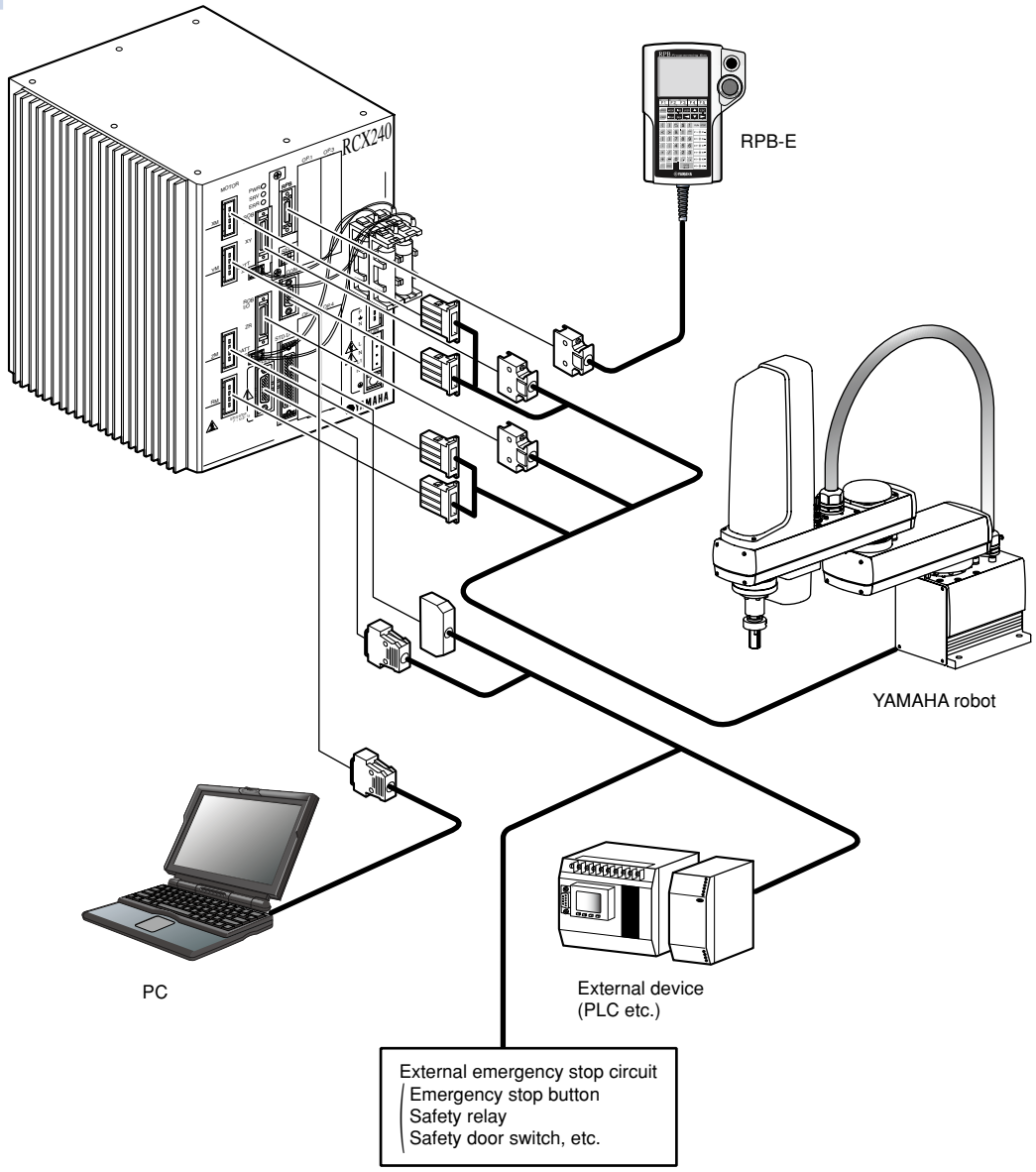
■ RCX240

Example: YK500XG only

All the axes on the robot controller are used as the main robot axes.

System for controlling one robot



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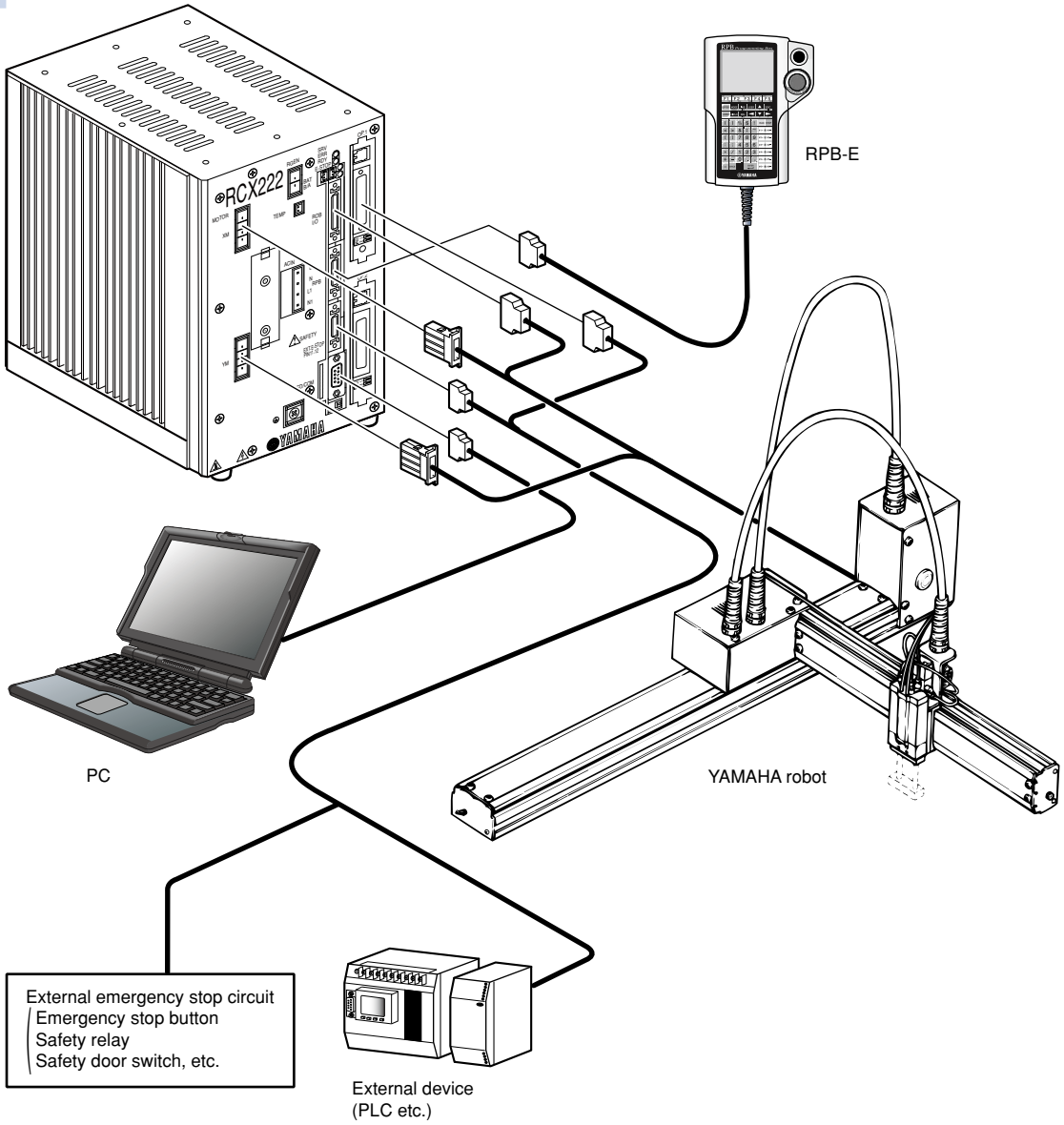
■ RCX221/RCX222

Example: XY-X series

System for controlling one robot



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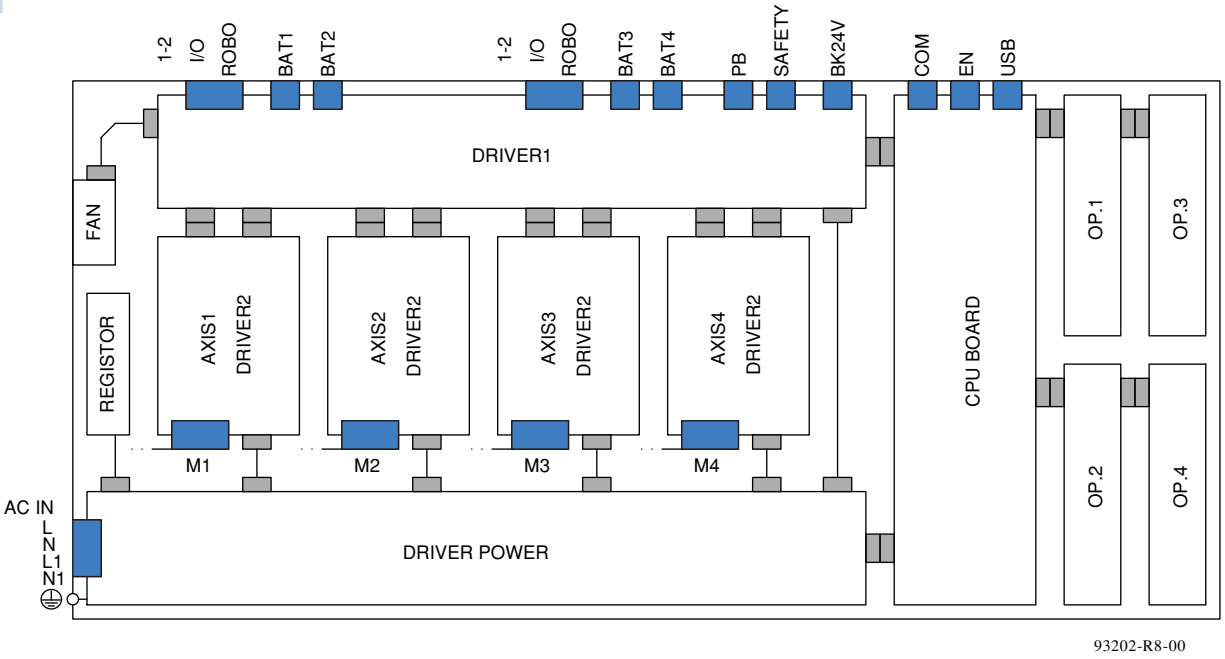
1.2 Control system configuration

1.2.1 Basic configuration

The basic block diagram of the RCX robot controller system is shown below.

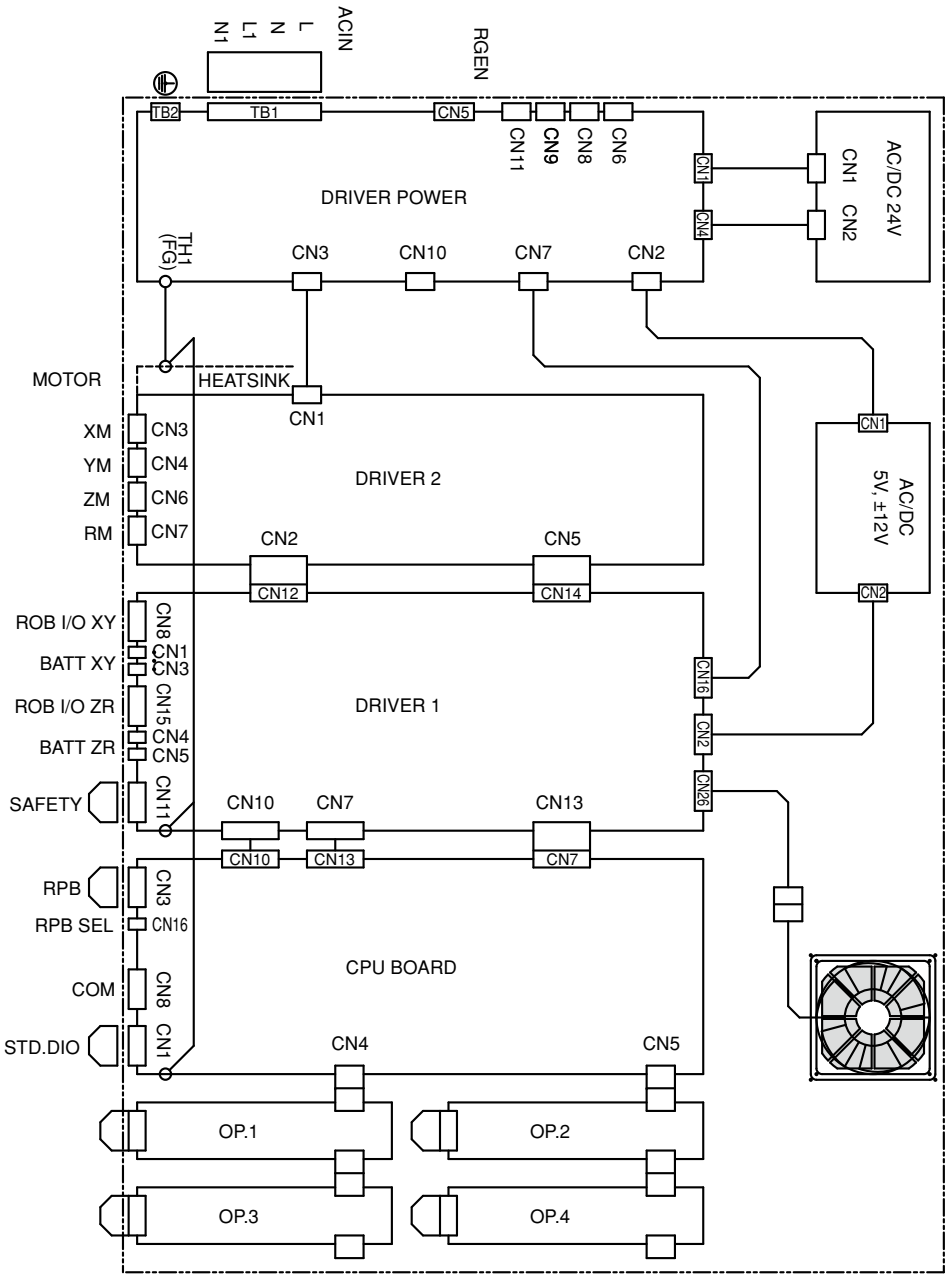
■ RCX340 basic block diagram

Basic block diagram



RCX240 basic block diagram

Basic block diagram



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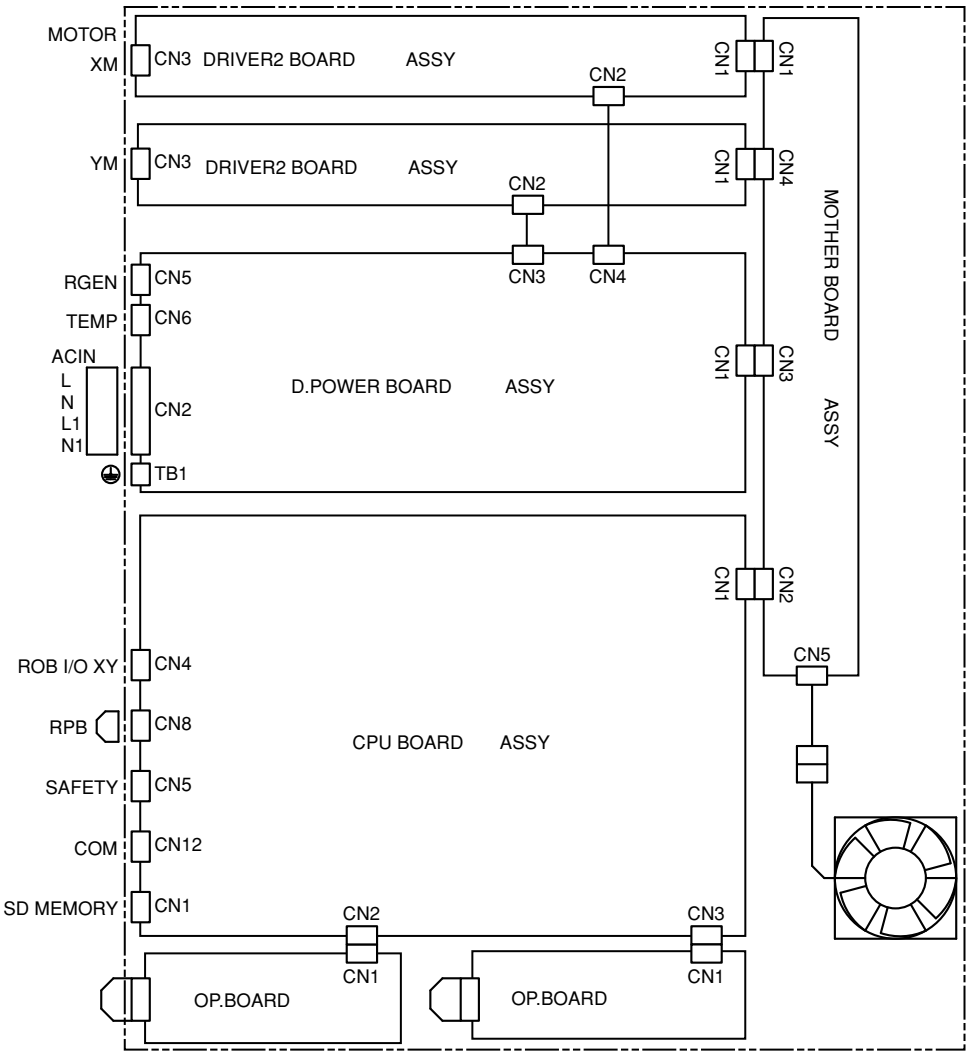
■ RCX221 basic block diagram

Basic block diagram



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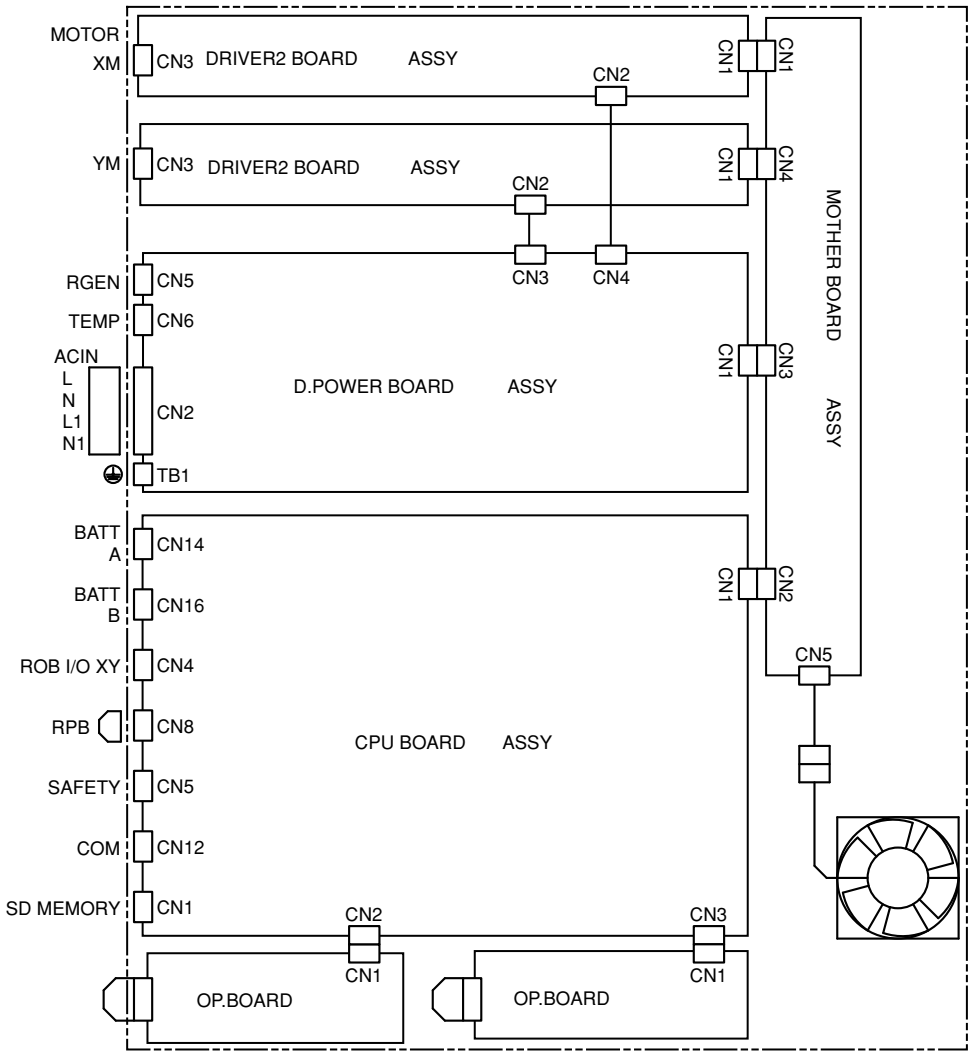
RCX222 basic block diagram

Basic block diagram



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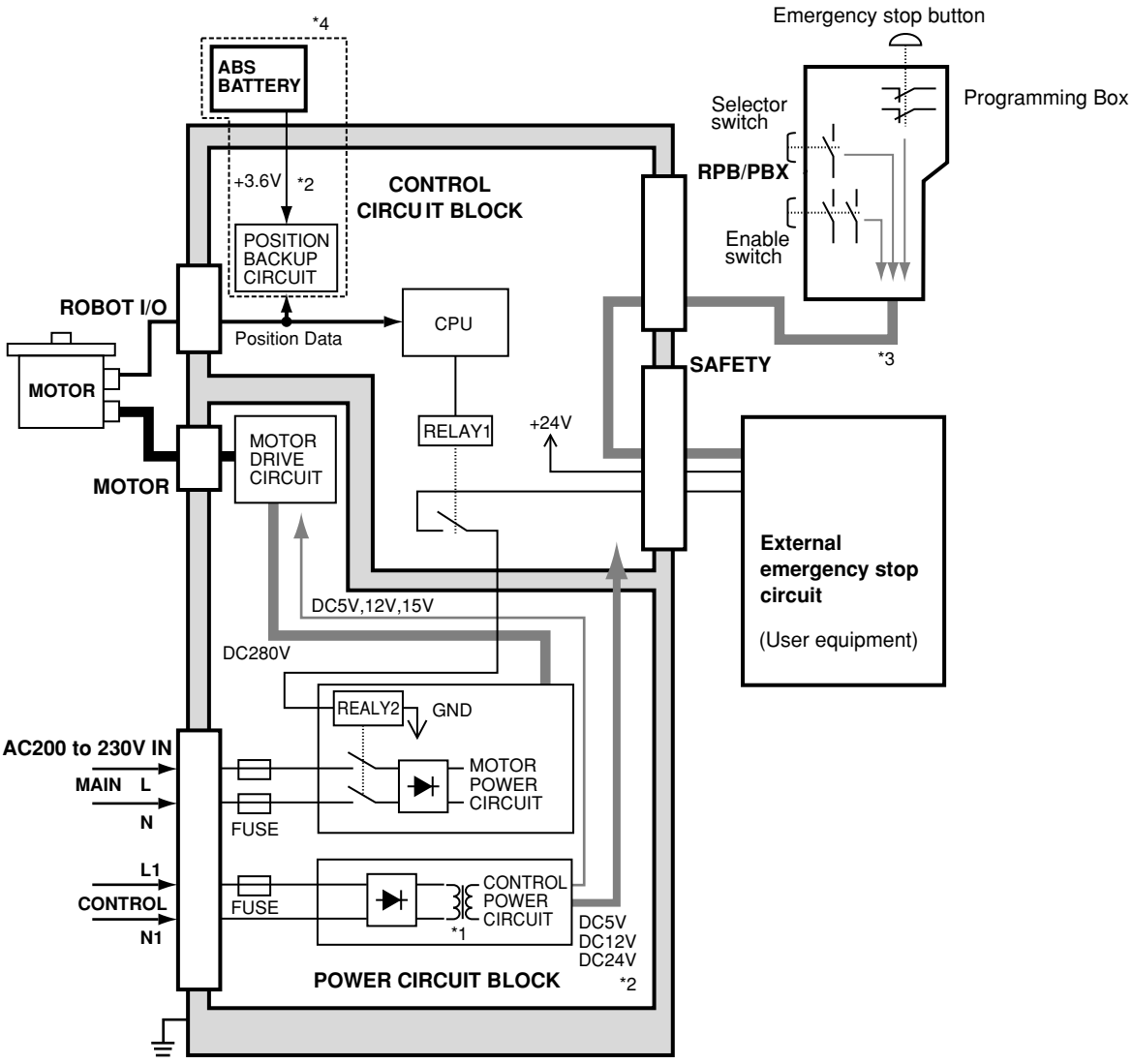
1.2.2 Power supply and emergency stop system circuit configuration

The control system's power supply system and emergency stop system circuit block diagram are shown below.

Power supply and emergency stop circuit block diagram



RCX340/RCX240/RCX221/RCX222

*1) The input power and each control power are insulated by the insulated transformer.

*2) The 0V line for the 3.6VDC, 5VDC, 12VDC and 24VDC is not connected to the protective earth.

*3) For details about wiring diagram from the programming box, refer to the connector input/output signal table.

*4) Excluding RCX221.

93201-R0-00

1.3 Programming box

The programming box is a hand-held unit specifically designed to connect to the controller, in order to perform various operations. The programming box allows all operations including manual operation of the robot, programming and editing, teaching, and parameter setting.

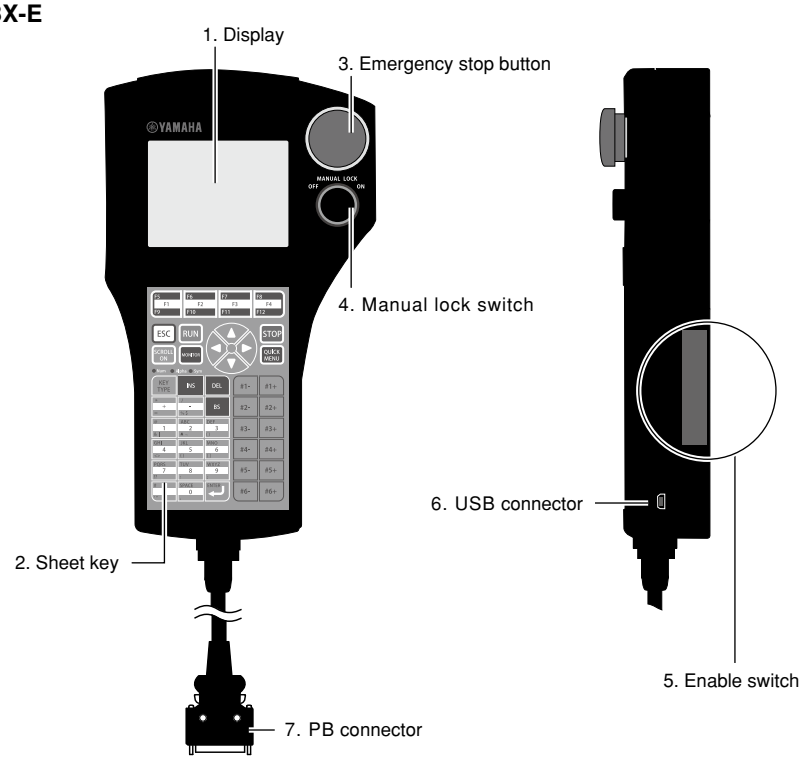
1.3.1 PBX-E

To use the programming box (PBX-E), connect it to the RCX340 series controller.

1.3.1.1 Part names and functions

The PBX-E has an emergency stop button and an enable switch. The contact outputs of these can be used to connect to the emergency stop circuit of the entire equipment via the SAFETY connector on the controller. Additionally, the PBX-E is equipped with a manual lock ON/OFF switch that sets the control priority.
When operating the teaching, etc. within the safety enclosure in the MANUAL mode, set the manual lock switch to “ON”.
When the manual lock switch is set at “ON”, the priority is set to the PBX-E, allowing you to control the robot operation. When the manual lock switch is set at “OFF”, the robot operation cannot be controlled.

PBX-E



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● **Main Functions**

No.	Part name	Function
1	Display	This is a liquid crystal display (LCD) with 20 characters × 15 lines, showing various types of information. The screen brightness is adjustable.
2	Sheet keys	These keys are used to operate a robot or input programs. The sheet keys are classified into 3 main types: function keys, control keys and data keys.
3	Emergency stop button	Pressing this button during operation immediately stops robot movement. This is a contact b (normally closed) type switch. The XA1E-BV302R made by IDEC is used.
4	Manual lock switch	This switch sets the priority that controls the robot operation. Be sure to set the switch to “ON” in the MANUAL mode. Selecting “ON” will set the priority to the PBX-E, allowing you to control the robot operation. When the switch is set at “OFF”, the robot operation cannot be controlled.
5	Enable switch	This is a 3-position switch designed in consideration of safety. Pressing this switch to the middle position only enables robot operation. When the ENABLE 11, 12, 21, and 22 wirings of the SAFETY connector are not connected, the function of this switch cannot be used. Configure an external safety circuit so that the state of this switch determines the robot operating state as follows: Switch released : Emergency stop state Switch in middle position : Operable state Switch pressed : Emergency stop state The A4E-B200HS made by OMRON is used.
6	USB connector	This connector is used to read/write between the USB memory and the internal memory of the controller. The connector is intended to connect the USB memory and programming box. The connector is used to save various data of the controller and perform the maintenance of the programming box.
7	PB connector	Use this connector to connect the PBX-E programming box to the robot controller.

1.3.1.2 PB connector

The PBX-E has an emergency stop button and an enable switch. The contact outputs of these can be used to connect to the emergency stop circuit of the entire equipment via the SAFETY connector on the controller. This section describes signal connections.

CAUTION

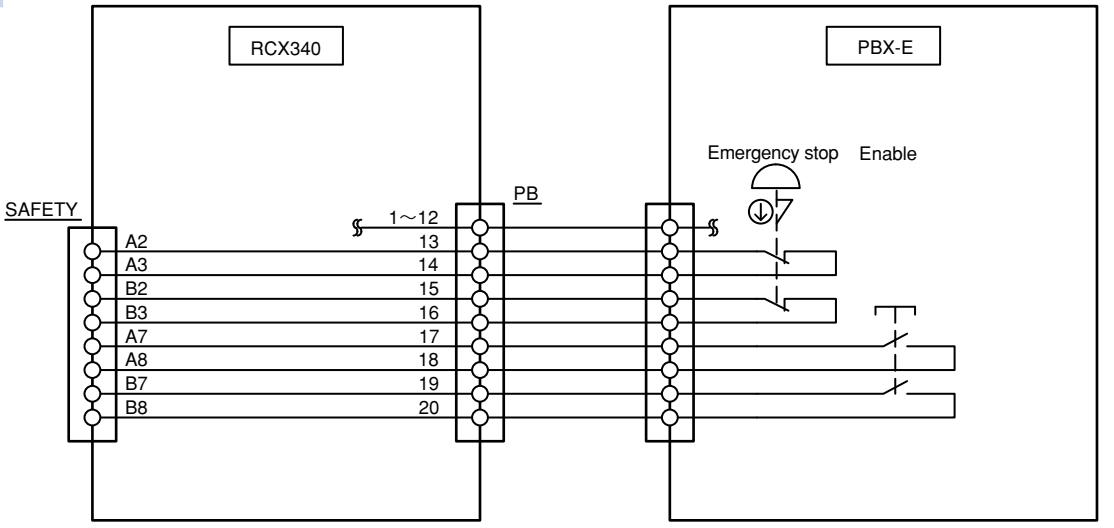
- **Do not change or modify the cable and connector. Along with the input/ output signals for the programming box, the PB connector includes signals used to configure an external safety circuit, and so changing or modifying the cable and connector is very dangerous.**
- **Always configure an external safety circuit by using the SAFETY connector. Although the PBX-E has an emergency stop button and an enable switch, they do not function independently because the controller is designed on the assumption that an external safety circuit is configured.**

■ RCX340

Each pin of the PB connector on the PBX-E is connected to the SAFETY connector.
Pin to pin connections are as follows:

PBX-E	PB connector pin No.	Connected connector	SAFETY connector pin No.	Name
Emergency stop contact: Line 1	13	Connected to SAFETY connector	A2	E-STOP11
	14		A3	E-STOP12
Emergency stop contact: Line 2	15		B2	E-STOP21
	16		B3	E-STOP22
Enable contact: Line 1	17		A7	ENABLE1+
	18		A8	ENABLE1-
Enable contact: Line 2	19		B7	ENABLE2+
	20		B8	ENABLE2-

Circuit diagram



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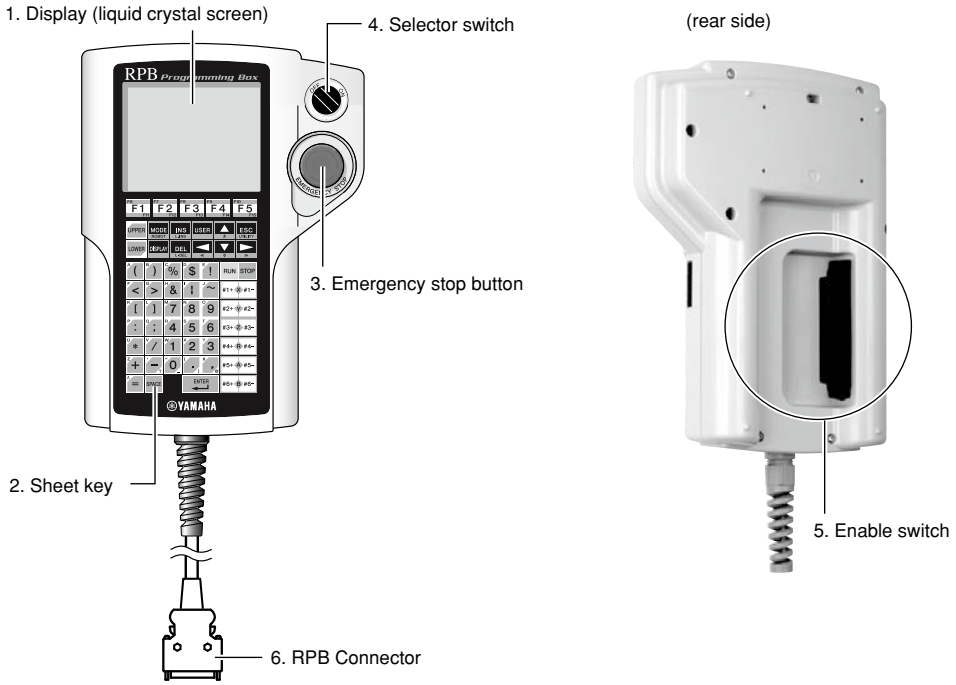
1.3.2 RPB-E

The programming box (RPB-E) is a hand-held unit specifically designed to connect to the controller, in order to perform various operations. The RPB-E allows all operations including manual operation of the robot, programming and editing, teaching, and parameter setting.

1.3.2.1 Part names and functions

The RPB-E has an emergency stop button and an enable switch. The contact outputs of these can be used to connect to the emergency stop circuit of the entire equipment via the SAFETY connector on the controller. The RPB-E also has a selector switch which can be used according to the customer's specifications and applications.

RPB-E



93202-R0-00

● **Main Functions**

No.	Part name	Function
1	Display (liquid crystal screen)	This is a liquid crystal display (LCD) with 40 characters × 15 lines, showing various types of information. The screen brightness is adjustable.
2	Sheet keys	These keys are used to operate a robot or input programs. The sheet keys are classified into 3 main types: function keys, control keys and data keys.
3	Emergency stop button	Pressing this button during operation immediately stops robot movement. This is a contact B (normally closed) type switch. The XA1E-BV302R made by IDEC is used.
4	Selector switch	This switch can be used as needed by wiring to the RPB SEL connector on the RCX240 or to the SAFETY connector on the RCX221/RCX222. Turning on this switch opens the contact, and turning it off closes the contact. The switch ON/OFF function is disabled if not wired.
5	Enable switch	This is a 3-position switch designed in consideration of safety. Pressing this switch to the middle position only enables robot operation. This switch is disabled when LOCKIN1 to 4 of the SAFETY connector are not wired. Configure an external safety circuit so that the state of this switch determines the robot operating state as follows: Switch released : Emergency stop state Switch in middle position : Operable state Switch pressed : Emergency stop state The HE2B-M200PB made by IDEC is used.
6	RPB connector	Use this connector to connect the RPB programming box to the robot controller.

1.3.2.2 RPB connector

The RPB-E has an emergency stop button and an enable switch. The contact outputs of these can be used to connect to the emergency stop circuit of the entire equipment via the SAFETY connector on the controller. This section describes signal connections.

CAUTION

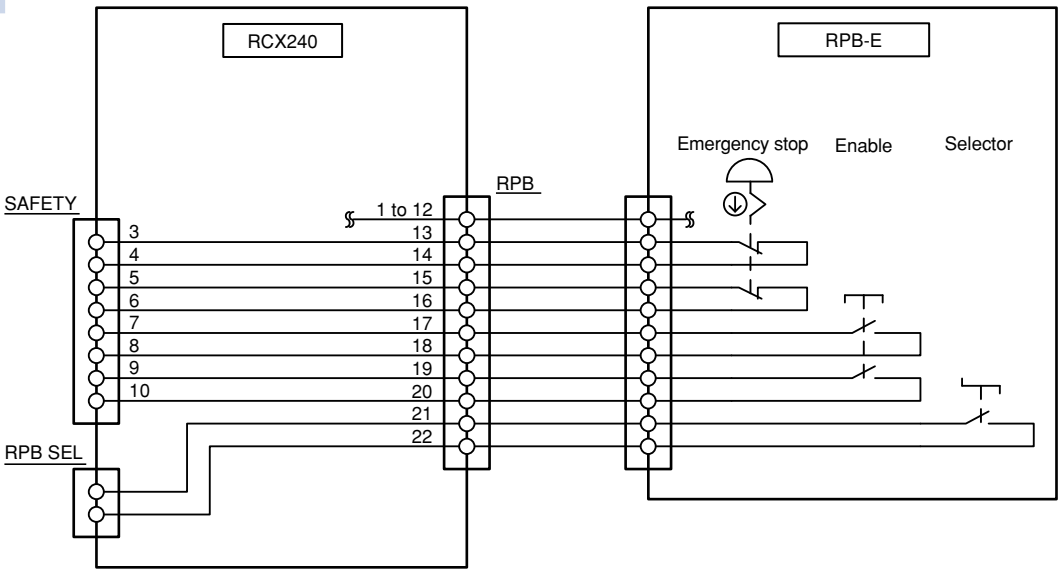
- **Do not change or modify the cable and connector. Along with the input/ output signals for the programming box, the RPB connector includes signals used to configure an external safety circuit, and so changing or modifying the cable and connector is very dangerous.**
- **Always configure an external safety circuit by using the SAFETY connector. Although the RPB-E has an emergency stop button and an enable switch, they do not function independently because the controller is designed on the assumption that an external safety circuit is configured.**

■ RCX240

Each pin of the RPB connector on the RPB-E is connected to each pin of the SAFETY connector and RPB SEL connector. Pin to pin connections are as follows:

RPB-E	RPB connector pin No.	Connected connector	Connector pin No.	Name
Emergency stop contact: Line 1	13	Connected to SAFETY connector	3	E-STOPIN1
	14		4	E-STOPIN2
Emergency stop contact: Line 2	15		5	E-STOPIN3
	16		6	E-STOPIN4
Enable contact: Line 1	17		7	LCKIN1
	18		8	LCKIN2
Enable contact: Line 2	19		9	LCKIN3
	20		10	LCKIN4
Selector switch	21	Connected to RPB SEL connector	–	KEY1
	22		–	KEY2

Circuit diagram



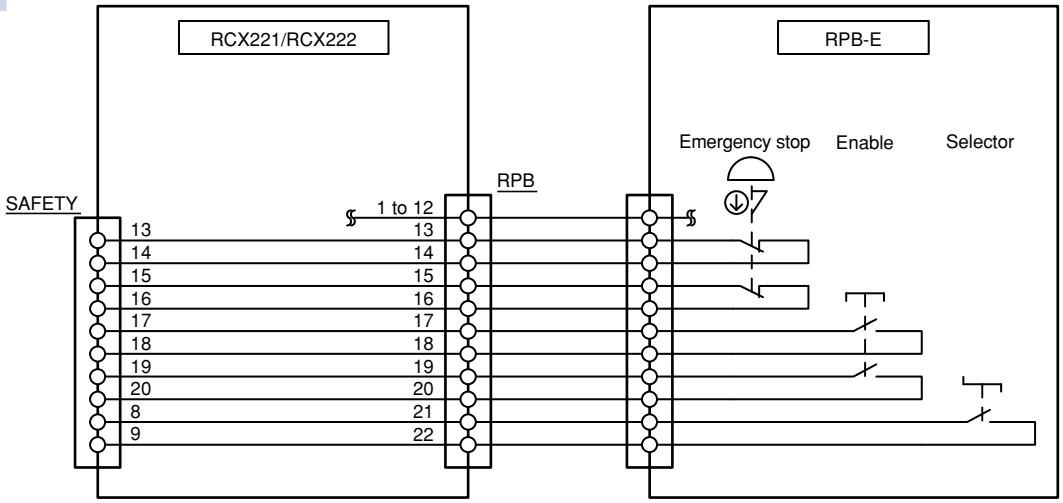
93203-R6-00

RCX221/RCX222

Each pin of the RPB connector on the RPB-E is connected to each pin of the SAFETY connector.
Pin to pin connections are as follows:

RPB-E	RPB connector pin No.	Connected connector	Connector pin No.	Name
Emergency stop contact: Line 1	13	Connected to SAFETY connector	13	E-STOPIN1
	14		14	E-STOPIN2
Emergency stop contact: Line 2	15		15	E-STOPIN3
	16		16	E-STOPIN4
Enable contact: Line 1	17		17	LCKIN1
	18		18	LCKIN2
Enable contact: Line 2	19		19	LCKIN3
	20		20	LCKIN4
Selector switch	21		8	KEY1
	22		9	KEY2

Circuit diagram



93202-R1-00

1.4 CE specifications and KCs specifications

The CE specifications and KCs specifications provide functions necessary for the work inside the safety enclosure that is applicable to the safety standards.
These functions are used when performing the work that uses the programming box (PBX-E/RPB-E) inside the safety enclosure of the robot system.

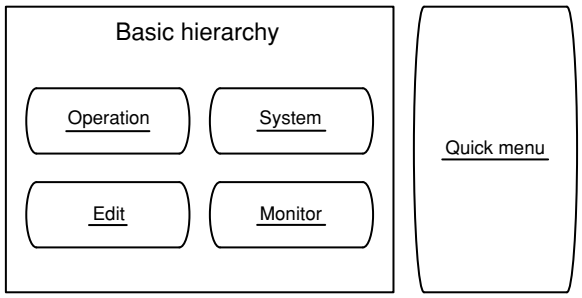
1.4.1 MANUAL mode (Applicable controller: RCX340)

The AUTO mode inputs of the SAFETY connectors A9, A10, B9, and B10 are used when performing the work with the PBX-E inside the safety enclosure of the robot system.
These AUTO mode inputs are enabled only with the CE specifications.
For the CE specifications, they have been set enabled before shipment.

CAUTION

The controllers applicable to the safety standards always have the CE specifications.

Basic operation mode



93207-R8-00

In the CE specifications, the AUTO mode and MANUAL mode are changed using the AUTO (AUTO mode) inputs of the SAFETY connector.
The operations inside four hierarchies may vary depending on the MANUAL mode and AUTO mode. For details, refer to the Operator's manual.

In the SAFETY connector, AUTO mode is entered when the contacts of AUTO1 and AUTO2 (AUTO mode input) are closed (high-level).
MANUAL mode is entered when these contacts are opened (low-level).
The controller is in MANUAL mode with the operation level, operating speed limit, and exclusive control of the operating devices specified by the MANUAL mode parameters. The following functions can be selected in MANUAL mode.

1. Robot is controlled only by PBX-E operation.
2. Automatic operation is prohibited.
3. Robot operating speed is set to below 3% of the maximum speed.
4. Robot operation is possible only by hold-to-run control.
   (The Hold-to-Run function allows the robot to move (including program execution) only during the time that the PBX-E operation key is kept pressed.)

WARNING

RESTRICTION ON THE ROBOT MOVING SPEED IS NOT A SAFETY-RELATED FUNCTION.
TO REDUCE THE RISK OF COLLISION BETWEEN THE ROBOT AND WORKERS, THE USER MUST TAKE THE NECESSARY PROTECTIVE MEASURES SUCH AS ENABLE DEVICES ACCORDING TO RISK ASSESSMENT BY THE USER.

NOTE

- If the AUTO mode input is changed during program operation or jog movement, the emergency stop is activated.
- The AUTO mode input specifications are PNP. The input current needs a capacity of 7mA or more.
- If the external 24V-power is not supplied, the controller always enters the MANUAL mode and the automatic operation cannot be performed.

1.4.1.1 MANUAL mode parameter settings

When the MANUAL mode parameters are edited and these setting results are not saved, the present settings still remain enabled until the controller power is turned off.
For details about how to set the MANUAL mode parameters, refer to the Operator's manual.

1. Operation device control in MANUAL mode

Set the operational devices.

Operation device	Setting	Description
Dedicated input	Enable*/ Disable	Sets whether or not the operation from the dedicated input is enabled.
RS-232C	Enable*/ Disable	Sets whether or not the operation from the RS-232C input is enabled.
Ethernet	Enable*/ Disable	Sets whether or not the operation from the Ethernet input is enabled.

* Initial values: All devices are set "Enable".

WARNING

TO REDUCE THE RISK OF UNEXPECTED OPERATION, DISABLE OPERATION DEVICES OTHER THAN THOSE TO BE USED.

CAUTION

Dedicated input is SI when a serial board is connected.

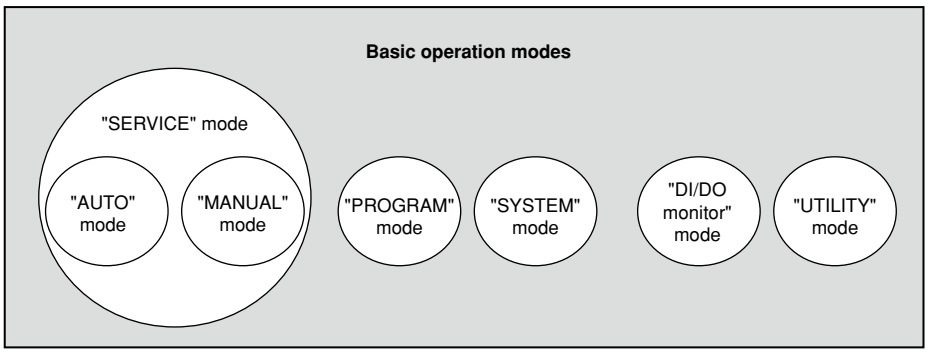
1.4.2 SERVICE mode (Applicable controller: RCX240/221/222/SR1)

SERVICE mode is used to perform work using the RPB-E within the safety enclosure of the robot system.
This mode is enabled only when the controller is set to SAFE mode. SAFE mode has been set at shipment. The controllers with the CE specifications and KCs specifications are set to SAFE mode.

CAUTION

The controllers with the CE specifications and KCs specifications must be set to SAFE mode.

Basic operation mode



93203-R0-00

SERVICE mode includes AUTO and MANUAL modes in the basic operation mode, and is selected by opening (turning OFF) the DI02 contact (SERVICE mode input). Normal mode is maintained as long as the DI02 contact is closed (ON).
If a serial I/O option board is installed, SERVICE mode is entered when either one of SI02 or DI02 is open (OFF). (Normal mode is entered only when both SI02 and DI02 contacts are closed.)

When the DI02 contact is open (OFF), the controller is in SERVICE mode with the operation level, operating speed limit, and exclusive control of the operating devices specified by the SERVICE mode parameters. The following functions can be selected in SERVICE mode.

1. Robot is controlled only by RPB-E operation.
2. Automatic operation is prohibited.
3. Robot operating speed is set to below 3% of the maximum speed.
4. Robot operation is possible only by hold-to-run control.
   (The Hold-to-Run function allows the robot to move (including program execution) only during the time that the RPB-E operation key is kept pressed.)

In SAFE mode setting, therefore, the operations in AUTO mode and MANUAL mode differ from those in normal mode, depending on the SERVICE mode parameter settings.

WARNING

**RESTRICTION ON THE ROBOT MOVING SPEED IS NOT A SAFETY-RELATED FUNCTION.
TO REDUCE THE RISK OF COLLISION BETWEEN THE ROBOT AND WORKERS, THE USER MUST TAKE THE NECESSARY PROTECTIVE MEASURES SUCH AS ENABLE DEVICES ACCORDING TO RISK ASSESSMENT BY THE USER.**

NOTE

- The robot pauses when the SERVICE mode input is changed during program operation or jog movement.
- The NPN/PNP specifi cations for DI02 are determined as follows:
  RCX240 Determined by STD.DIO setting.
  RCX221/RCX222 Determined by DI.COM and DO.COM input.
- Current capacity of at least 7mA is required for DI02 input.
- When the RCX240 controller is set to SAFE mode, it always enters the SERVICE mode unless power is supplied to STD.DIO from the external 24 V power supply. To cancel this state by software, set the "Watch on STD.DIO DC24V" parameter to "INVALID".

1.4.2.1 Flow for enabling the SERVICE mode functions

- Controller is set to SAFE mode.
- SERVICE mode parameters have been set.

↓

- Open (turn OFF) the DI02 contact.
  (If a serial I/O option board is installed, SERVICE mode is entered when either one of SI02 or DI02 is open (OFF).)

↓

- Controller enters SERVICE mode with the operation level, operating speed limit, and exclusive control of the operation devices specified by the SERVICE mode parameters.

Refer to the next section for the SERVICE mode parameter settings.

1.4.2.2 SERVICE mode parameter settings

There are the following three parameters for SERVICE mode.

1. SERVICE mode level
2. Operating speed limit during SERVICE mode
3. Operation device control during SERVICE mode

These parameter settings determine the operation level, operating speed limit, and exclusive control of the operation devices during SERVICE mode.

Even after editing the SERVICE mode parameters, the present settings still remain enabled until the controller power is turned off unless the edited parameters are saved.
For how to set the SERVICE mode parameters, refer to the controller user's manual.

WARNING

CHANGING THE SERVICE MODE PARAMETERS FORM THEIR DEFAULT SETTINGS IS LIKELY TO INCREASE THE RISK TO PERSONNEL OPERATING OR MAINTAINING THE ROBOT. THESE PARAMETERS CAN BE CHANGED IF THE CUSTOMER ASSUMES RESPONSIBILITY, BUT EXTRA CAUTION SHOULD BE TAKEN TO ENSURE SAFETY.

1. SERVICE mode level

The SERVICE mode level can be selected to enable or disable the Hold-to-Run function and to permit or prohibit the operation in AUTO mode.
The Hold-to-Run function allows the robot to move (including program execution) only during the time that the RPB-E operation key is kept pressed.

	Setting	Description	
		Hold-to-Run function	AUTO mode operation
	Level 0	Disabled	Permitted
	Level 1	Enabled	Permitted
	Level 2	Disabled	Prohibited
*	Level 3	Enabled	Prohibited

* Default setting

2. Limitations on operating speed during SERVICE mode

The maximum robot operating speed can be specified.

	Setting	Description
*	<3%	Robot operating speed is limited to below 3% of maximum speed.
	<100%	Robot operating speed is not limited.

*Default setting

3. Operation device control during SERVICE mode

The operation device can be specified.

	Setting	Description
*	RPB	Only RPB-E operation is enabled.
	RPB/DI	RPB-E and dedicated input are enabled.
	RPB/COM	RPB-E and online commands are enabled.
	ALL	RPB-E, dedicated input, and online command operation device are enabled.

*Default setting

CAUTION

Dedicated input is SI when a serial board is connected.

2. EMC countermeasure examples

Regarding EMC Directive, the customer's final product (entire system) including the YAMAHA robot must provide the necessary countermeasures. We at YAMAHA determine a model for single units of YAMAHA robots (controller, robot, and peripheral device) and verify that it complies with the relevant standards of EMC Directive.
In order to ensure the customer's final product (entire system) complies with EMC Directive, the customer should take appropriate EMC countermeasures. Typical EMC countermeasures for a single unit of YAMAHA robot are shown for reference.

CAUTION

The following description and circuits are typical countermeasures used when the robot and controller are tested under YAMAHA installation conditions. When the robot and controller are used while installed in the customer's system, the actual test results may differ depending on installation conditions.

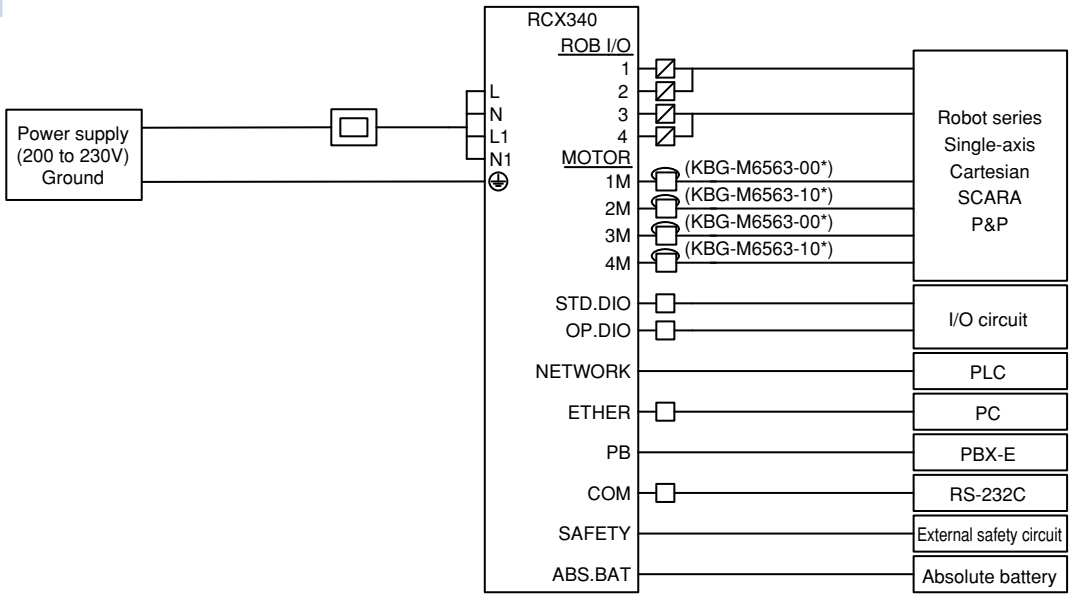
2.1 RCX340

2.1.1 Configuration

CAUTION

As shown in the following figure, the ferrite cores and noise filter on the controller side should be placed as close to the controller body as possible. The ferrite cores on the robot side should be placed as close to the robot body as possible.

Typical component layout for EMC countermeasures



Meaning of symbols

: Noise filter NF2020A-UP: SOSHIN ELECTRIC CO., LTD. or RSHN-2016: TDK-Lambda
: Ferrite core ZCAT3035-1330 : TDK
: Ferrite core ZCAT2132-1130 : TDK

: Ferrite core 1 turn
: Ferrite core 2 turns

93208-R8-00

2.1.2 Countermeasure components

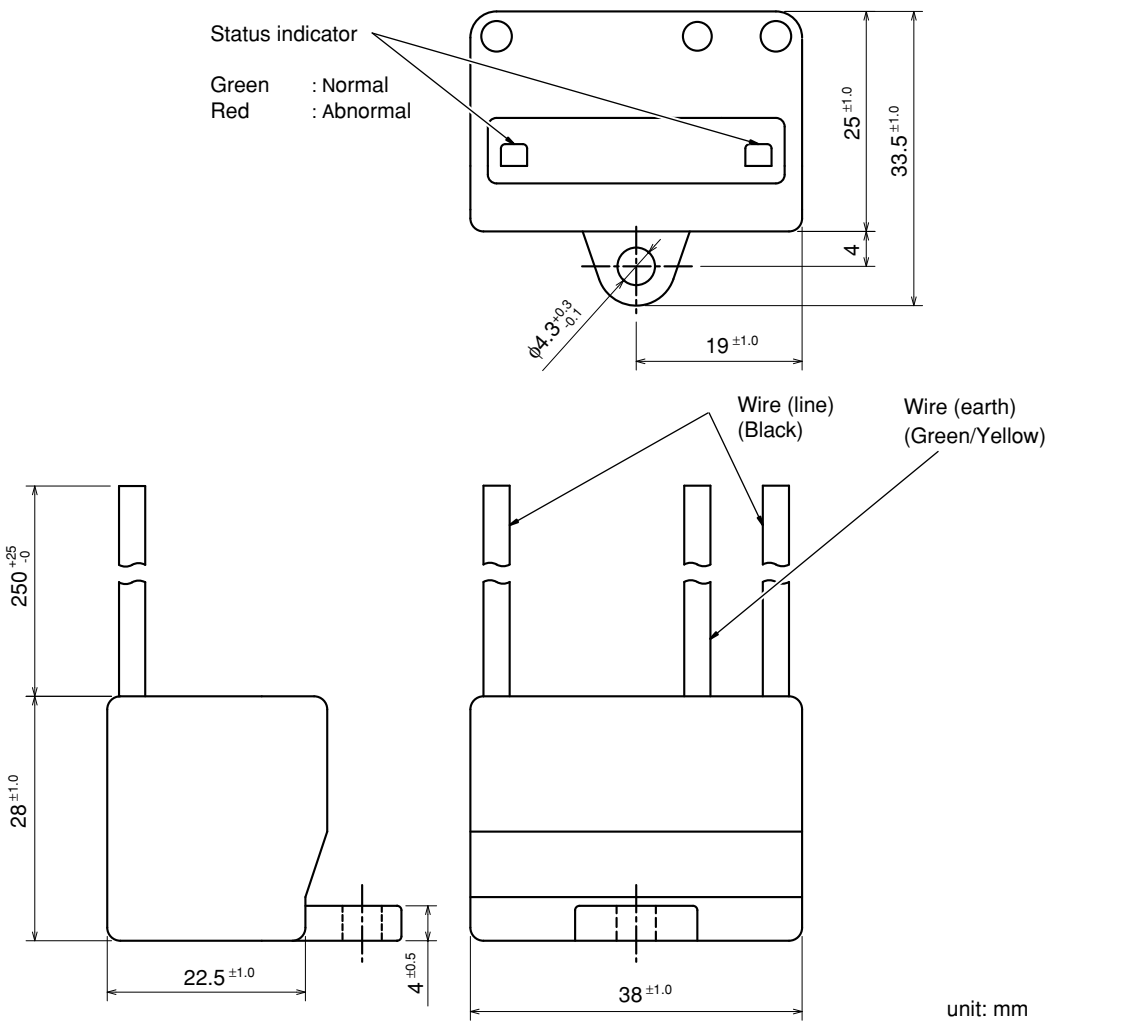
■ Surge absorber

The RCX340 does not need any external surge absorber. However, to further enhance the surge resistance, install a surge absorber on the AC power line.
A recommended surge absorber is shown below.

● Recommended surge absorber

Manufacturer : SOSHIN ELECTRIC CO., LTD.
Type No. : LT-C12G801WS

Dimensional outline



93205-R6-00

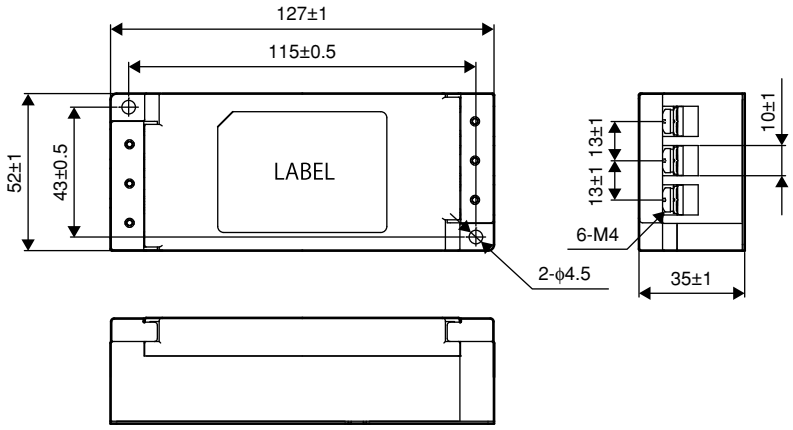
Noise filter

Always install an external noise filter on the AC power line.
A recommended noise filter is shown below.

● Recommended noise filter

Manufacturer : TDK-Lambda Corporation
Type No. : RSHN-2016

Dimensional outline



23218-QL-00

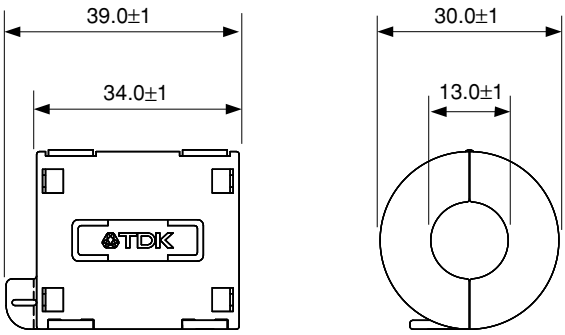
Ferrite core

Install ferrite cores according to the customer's final product (entire system).
Recommended ferrite cores are shown below.

● Recommended ferrite core 1

Manufacturer : TDK
Type No. : ZCAT3035-1330

Dimensional outline



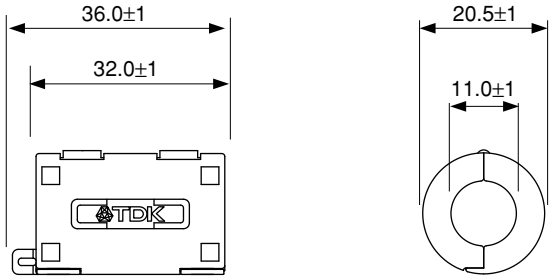
unit: mm

93207-R6-00

● Recommended ferrite core 2

Manufacturer : TDK
Type No. : ZCAT2132-1130

Dimensional outline



unit: mm

93208-R6-00

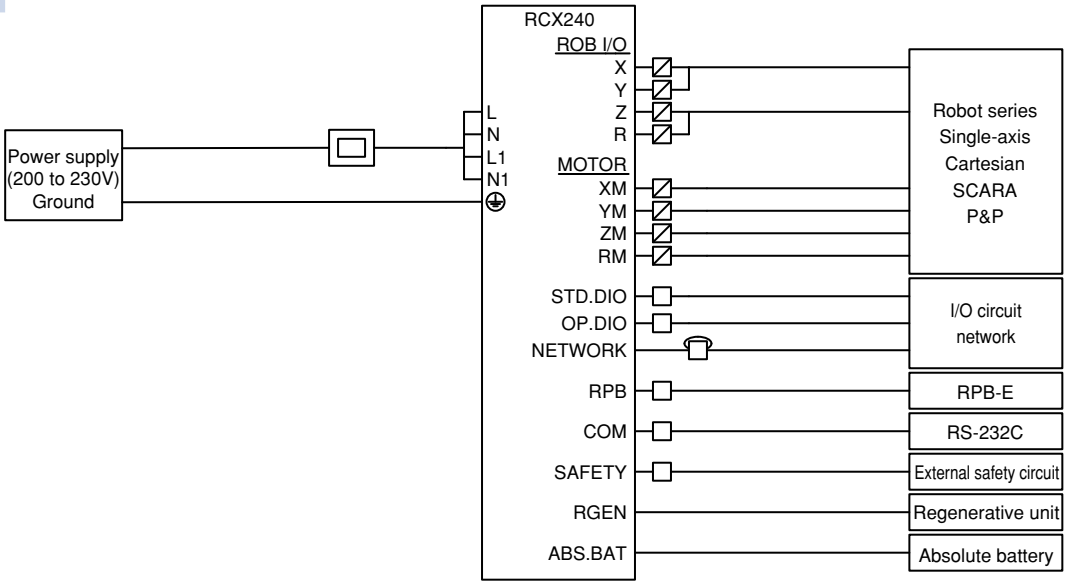
2.2 RCX240

2.2.1 Configuration

CAUTION

As shown in the following figure, the ferrite cores and noise filter on the controller side should be placed as close to the controller body as possible. The ferrite cores on the robot side should be placed as close to the robot body as possible.

Typical component layout for EMC countermeasures



Meaning of symbols

: Noise filter NF2020A-UP: SOSHIN ELECTRIC CO., LTD. or RSHN-2020: TDK-Lambda

: Ferrite core ZCAT3035-1330 : TDK

: Ferrite core ZCAT2132-1130 : TDK

: Ferrite core 1 turn

: Ferrite core 2 turns

93204-R6-00

2.2.2 Countermeasure components

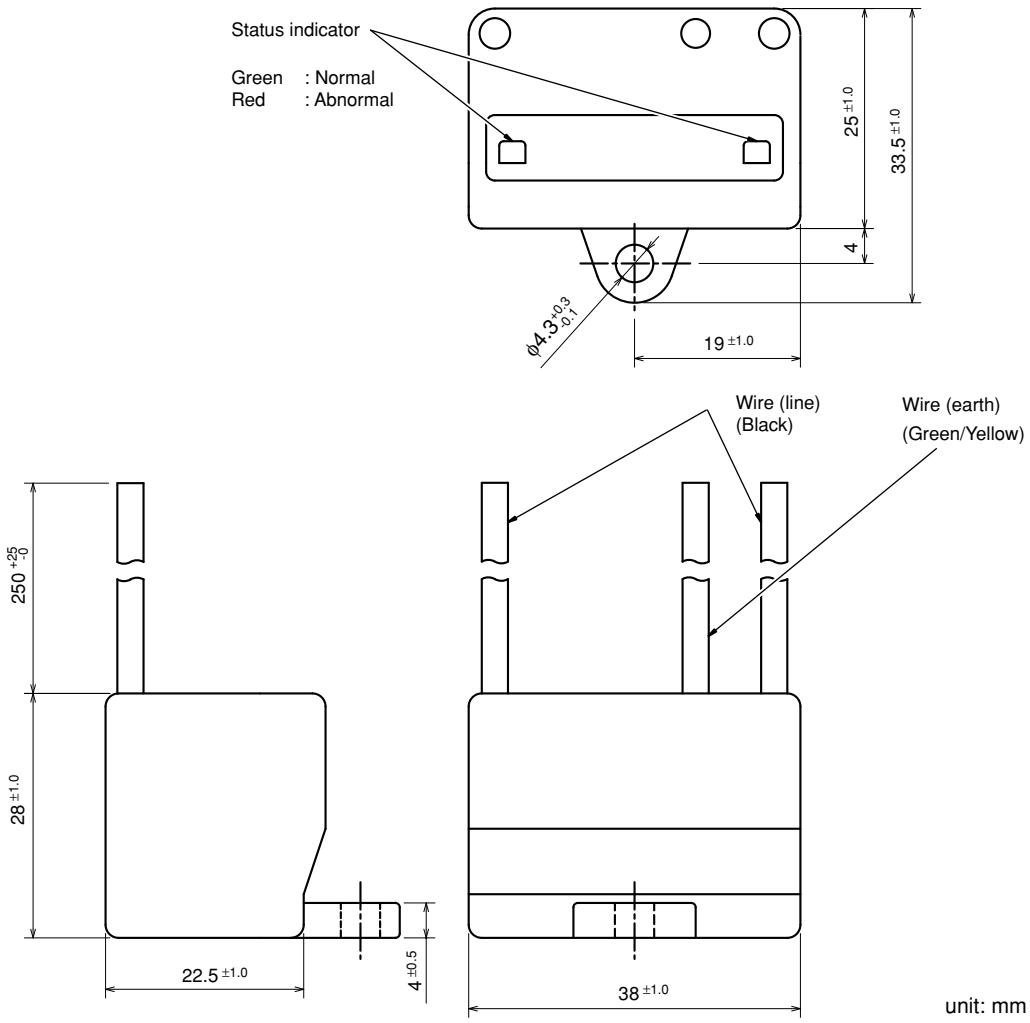
■ Surge absorber

The RCX240 does not need any external surge absorber. However, to further enhance the surge resistance, install a surge absorber on the AC power line.
A recommended surge absorber is shown below.

● Recommended surge absorber

Manufacturer : SOSHIN ELECTRIC CO., LTD.
Type No. : LT-C12G801WS

Dimensional outline



unit: mm

93205-R6-00

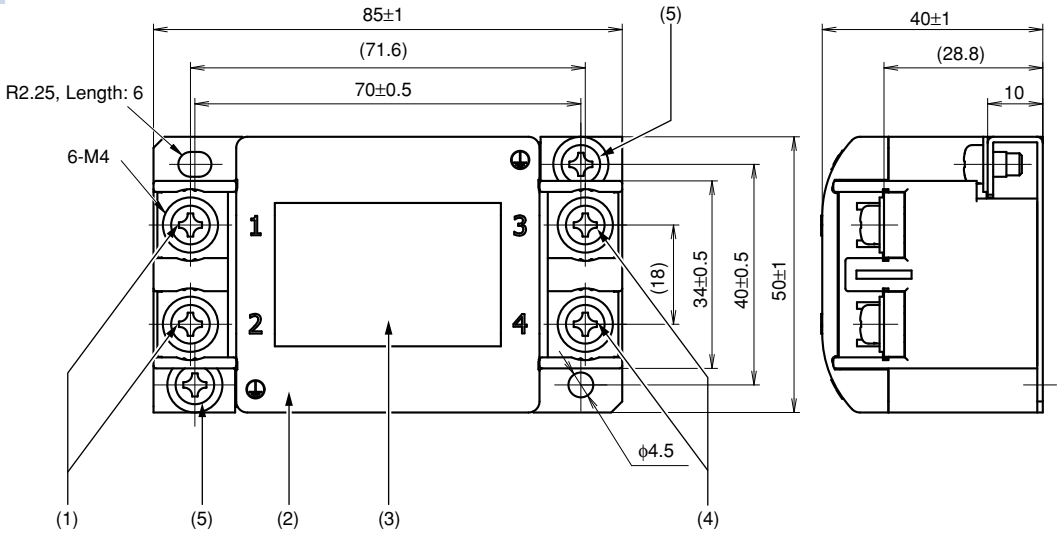
■ Noise filter

Always install an external noise filter on the AC power line.
A recommended noise filter is shown below.

● Recommended noise filter 1

Manufacturer : SOSHIN ELECTRIC CO., LTD.
Type No. : NF2020A-UP

Dimensional outline



No.	Part name	Note
(1)	Input terminal	M4
(2)	Case	PBT
(3)	Name plate	
(4)	Output terminal	M4
(5)	Earth terminal	M4

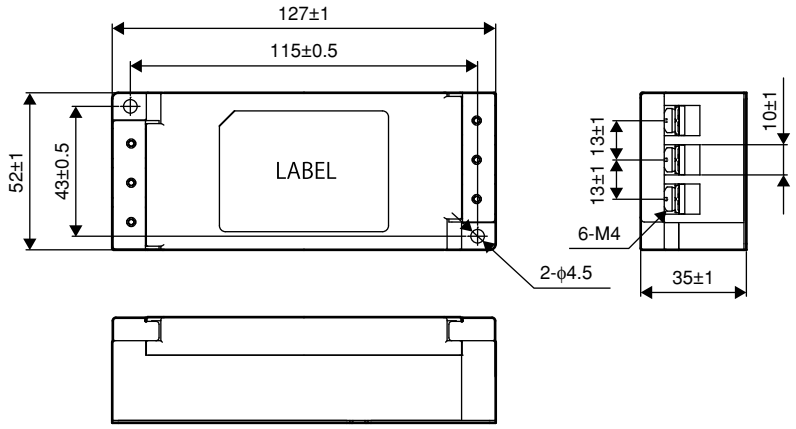
unit: mm

93206-R6-00

● Recommended noise filter 2

Manufacturer : TDK-Lambda Corporation
Type No. : RSHN-2016

Dimensional outline



23218-QL-00

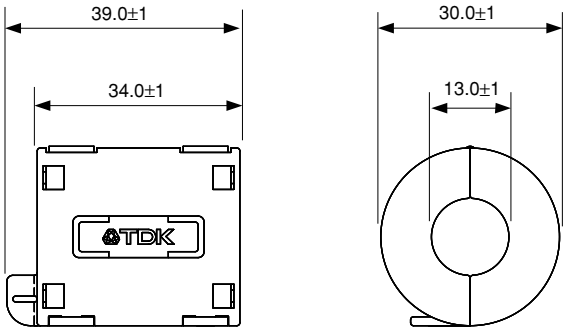
■ Ferrite core

Install ferrite cores according to the customer's final product (entire system).
Recommended ferrite cores are shown below.

● Recommended ferrite core 1

Manufacturer : TDK
Type No. : ZCAT3035-1330

Dimensional outline



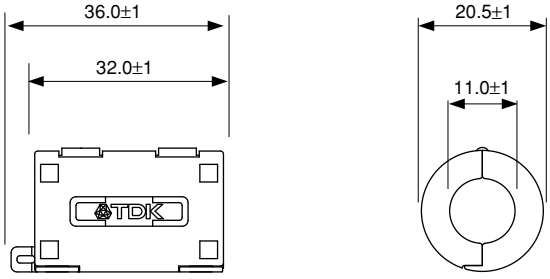
unit: mm

93207-R6-00

● Recommended ferrite core 2

Manufacturer : TDK
Type No. : ZCAT2132-1130

Dimensional outline



unit: mm

93208-R6-00

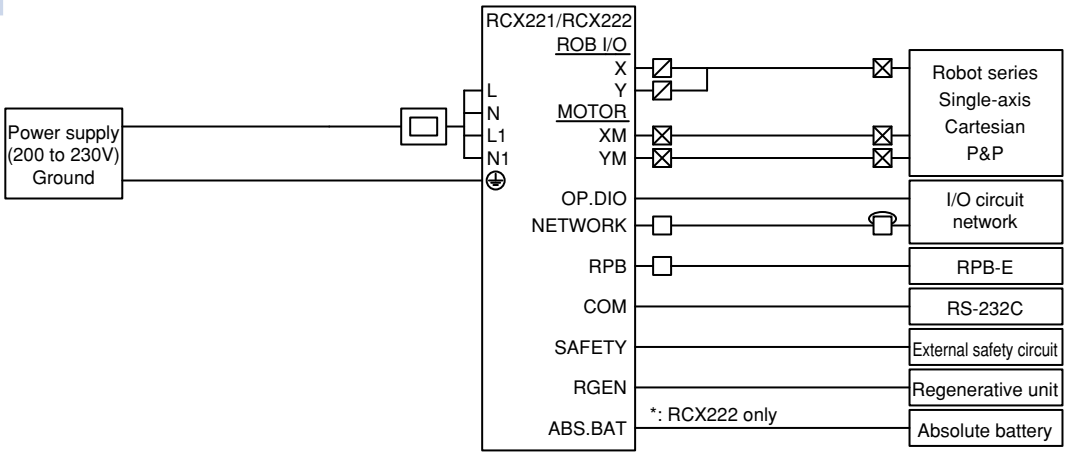
2.3 RCX221/RCX222

2.3.1 Configuration

CAUTION

As shown in the following figure, the ferrite cores and noise filter on the controller side should be placed as close to the controller body as possible. The ferrite cores on the robot side should be placed as close to the robot body as possible.

Typical component layout for EMC countermeasures



Meaning of symbols

: Noise filter MBS1215-22 : TDK-Lambda Corporation
: Ferrite core ZCAT3035-1330 : TDK
: Ferrite core ZCAT2132-1130 : TDK
: Ferrite core ZCAT2032-0930 : TDK
: Ferrite core 1 turn
: Ferrite core 2 turn

93203-R1-00

2.3.2 Countermeasure components

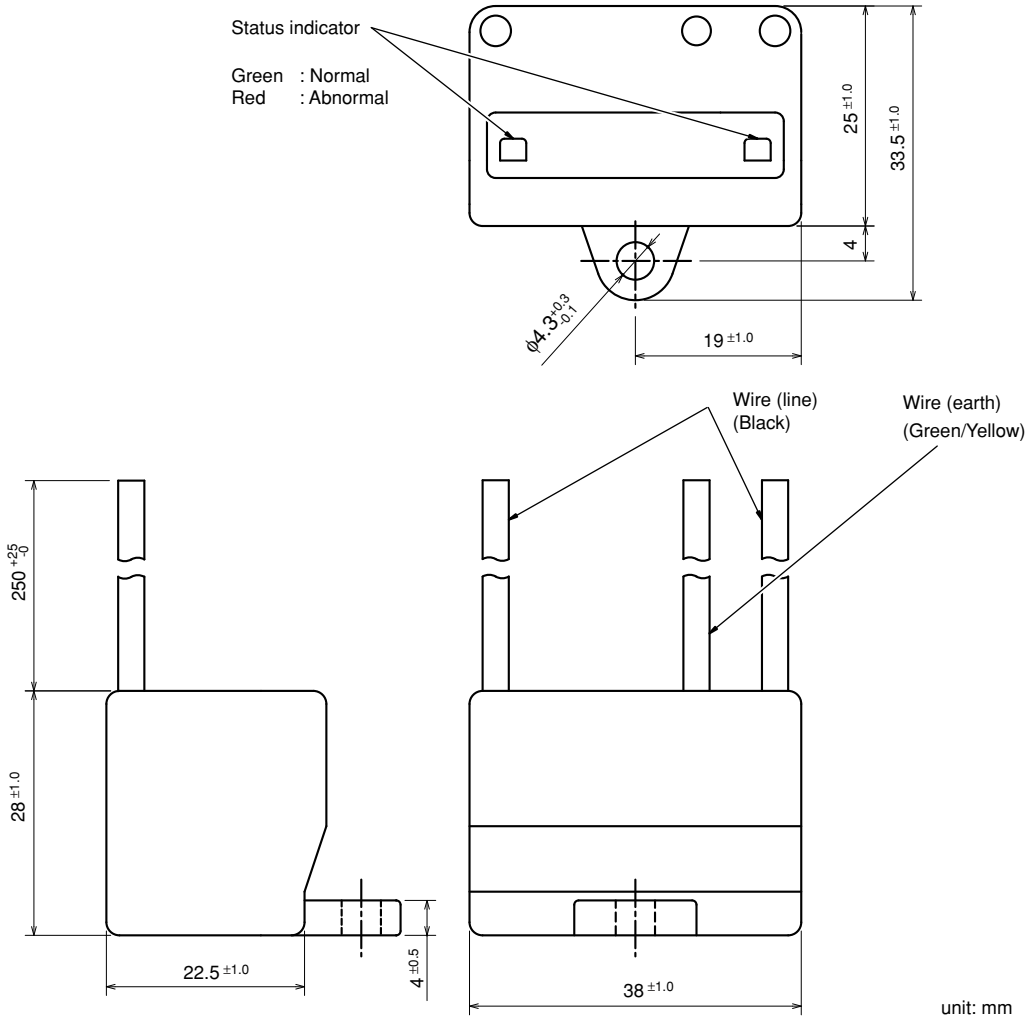
■ Surge absorber

The RCX221/222 does not need any external surge absorber. However, to further enhance the surge resistance, install a surge absorber on the AC power line.
A recommended surge absorber is shown below.

● Recommended surge absorber

Manufacturer : SOSHIN ELECTRIC CO., LTD.
Type No. : LT-C12G801WS

Dimensional outline



93204-R1-00

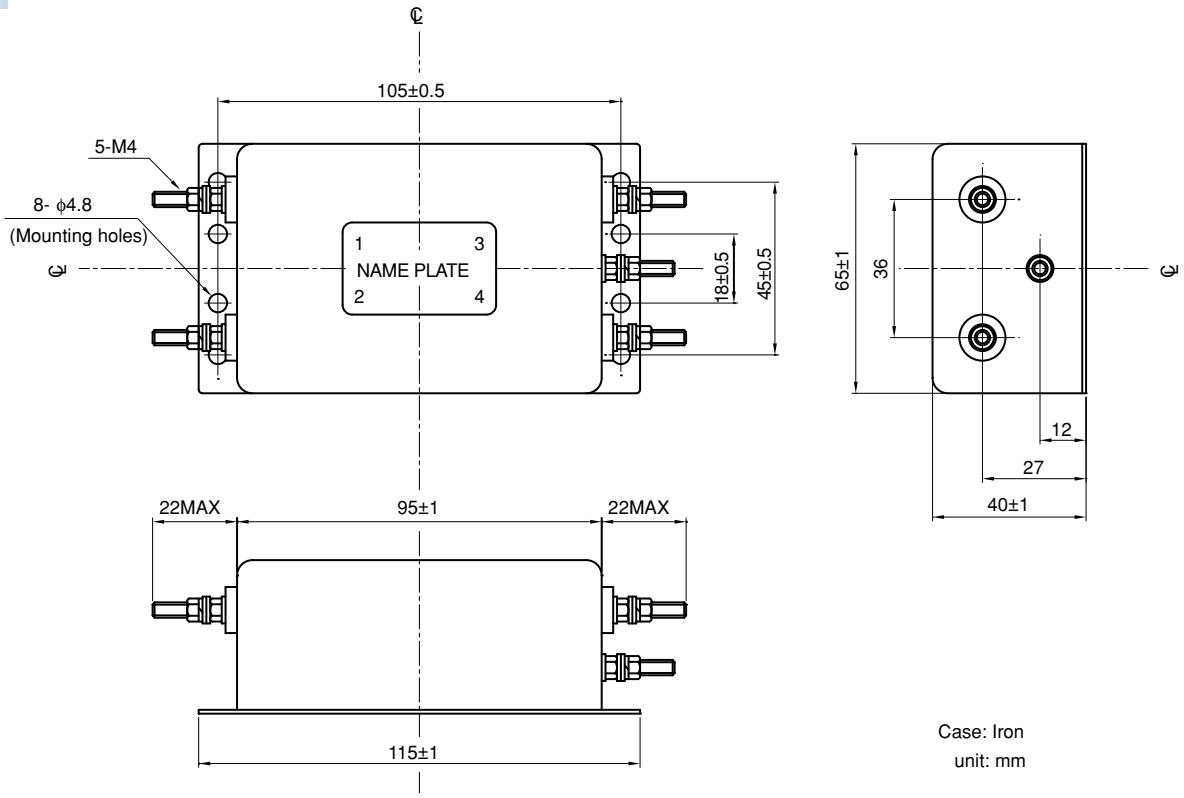
■ Noise filter

Always install an external noise filter on the AC power line.
A recommended noise filter is shown below.

● Recommended noise filter

Manufacturer : TDK-Lambda Corporation
Type No. : MBS-1215-22

Dimensional outline



Case: Iron
unit: mm

93205-R1-00

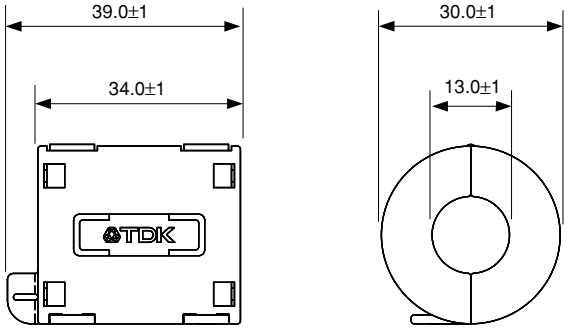
Ferrite core

Install ferrite cores according to the customer's final product (entire system).
Recommended ferrite cores are shown below.

● Recommended ferrite core 1

Manufacturer : TDK
Type No. : ZCAT3035-1330

Dimensional outline



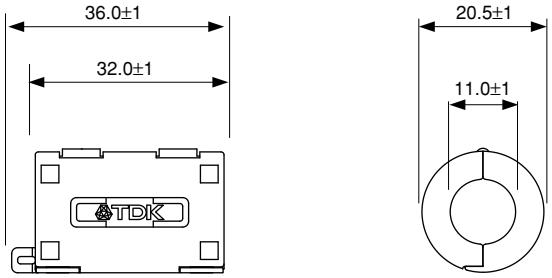
unit: mm

93206-R1-00

● Recommended ferrite core 2

Manufacturer : TDK
Type No. : ZCAT2132-1130

Dimensional outline



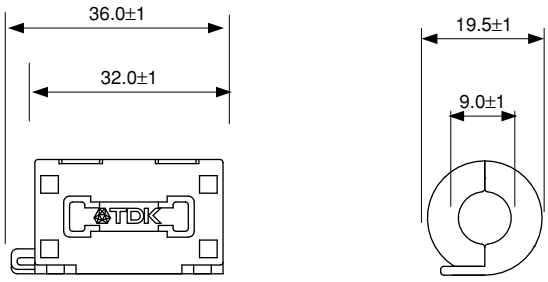
unit: mm

93207-R1-00

● Recommended ferrite core 3

Manufacturer : TDK
Type No. : ZCAT2032-0930

Dimensional outline



unit: mm

93208-R1-00

3. External safety circuit examples

This section describes category-specific safety circuit configuration examples using the PBX-E/RPB-E.
Customers should install the appropriate safety measures for their system by referring to the circuit example for each controller, in order to use the robots more safely.
To comply with the robot safety standards "EN ISO 10218-1:2011", it is necessary to use a SAFETY controller.
Circuit examples for the RCX221/222 controller and SR1 controller are not circuits that comply with "EN ISO 10218-1:2011" and are applicable only to the category requirements of "EN ISO 13849-1:2006".

3.1 Safety requirements

3.1.1 CE marking

To comply with the machinery directives, the "performance level (PL)" required of the safety circuit must be evaluated.
Performance levels (PL) are determined by the following parameters:

● **Major factors that determine performance levels**

1. Category
2. MTTFd (Mean Time To Dangerous Failure)
3. DCavg (Average Diagnostic Coverage)
4. CCF (Common Cause Failure) : Checklist score > 65 ?

(Please obtain the data on each component from the component manufacturer.)

The performance level (PL) of a safety circuit is determined by the following flow.

● **Flow for determining performance levels**

1. Determine the "performance level (PLr) required of the safety circuit" by means of risk assessment.
2. Configure the safety circuit that satisfies the requirements of the category that meets PLr.
3. Calculate the safety circuit's "performance level (PL)" from the MTTFd, DCavg, and CCF of the devices used for the safety circuit, and then make sure that the calculated PL is equal to or higher than the "performance level (PLr) required of the safety circuit" (PLr ≤ PL).

> In the customer's final system, the performance level (PLr) required of the safety circuit should be determined by means of risk assessment, and then the safety circuit with the corresponding performance level (PL) should be configured.

● **Safety parts subject to performance level calculation**

The table below shows the safety parts and B10d reference values.

CAUTION
Please obtain the latest information from the parts manufacturers.

	Parts Name	Model Name	Maker	B10d
PBX-E	Emergency stop button	XA1E-BV302R	IDEC	1×10^5
	Enable switch	A4E-B200HS	OMRON	1×10^5
RPB-E	Emergency stop button	XA1E-BV302R	IDEC	1×10^5
	Enable switch	HE2B-M200PB	IDEC	1×10^5

3.1.2 KCs mark

To comply with South Korea's Ministry of Employment and Labor Notification, it is necessary to evaluate the performance "category" required for the safety circuit through the risk assessments.

> In the customer's final system, the category required of the safety circuit should be determined by means of risk assessment, and then the safety circuit with the corresponding category should be configured.

3.2 Circuit examples for the RCX340

The following shows safety circuit configuration examples for the RCX340.
Customers should install the appropriate safety measures for their system by referring to these safety circuit configuration examples in order to use the robots more safely.
The following shows an example with input/output signals described below.

Input	Operation mode switch, door switch, external emergency stop, PBX-E emergency stop, PBX-E enable, MPRDY
Output	Contactor, E-STOPRDY, AUTO

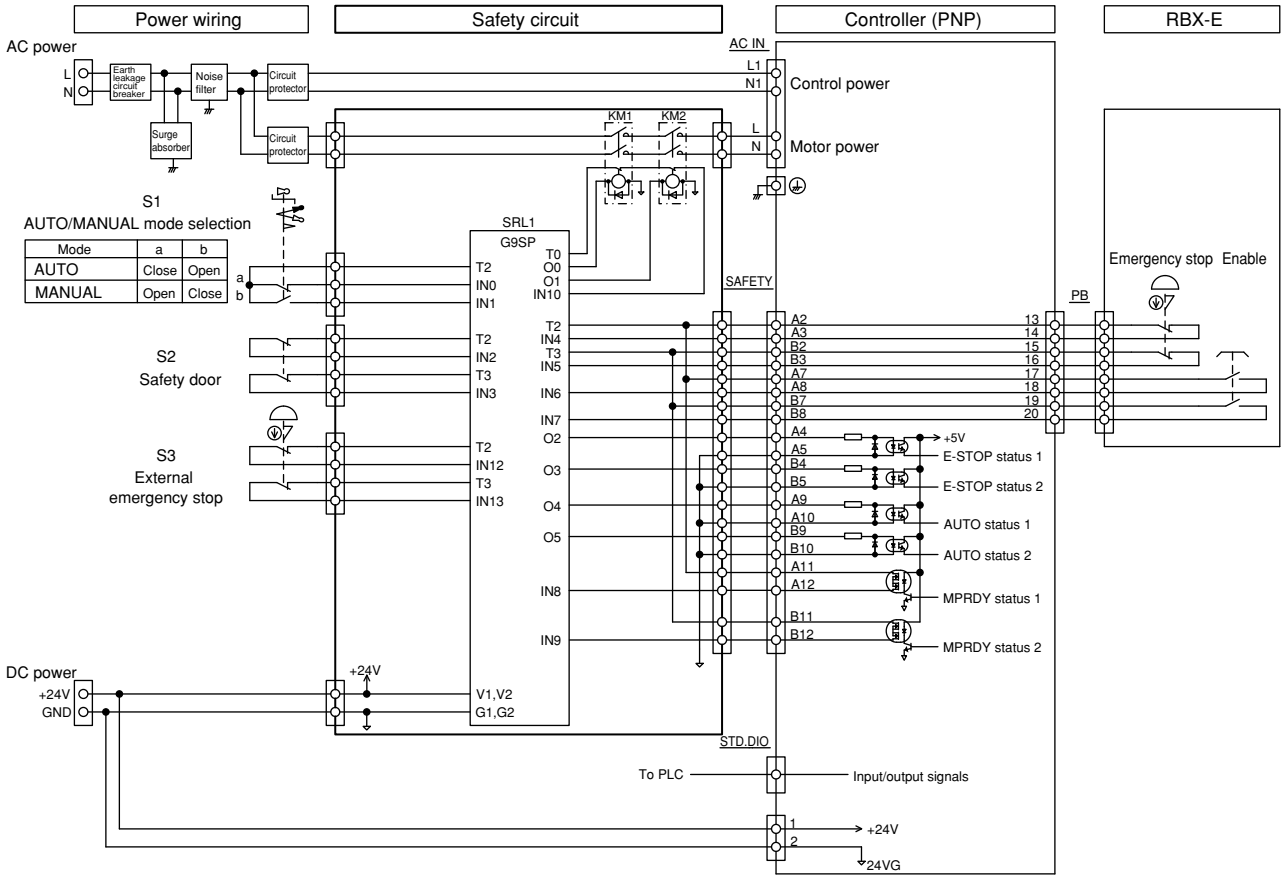
CAUTION

The controller status output signals of the parallel I/O and serial I/O, such as alarm signal should be monitored by the host device or safety controller.

3.2.1 Category 3

A safety circuit configuration example of category 3 is shown below.

Category 3 safety circuit example



Parts list

Circuit No.	Part name	Type No.	Manufacturer
S1	Key selector switch	A22TK series	OMRON
S2	Safety door switch	D4 series	OMRON
S3	Emergency stop button	A22E series	OMRON
KM1, 2	Contactor (mirror contact)	3RT2018-1FB42	SIEMENS
SRL1	Safety controller	G9SP series	OMRON

3.2.2 Overview of circuit operation

This section describes an overview of the circuit operation for each safety circuit configuration example shown in the previous sections.

The safety controller is programmed so that the operation is performed in the table below.
Additionally, the safety controller is programmed so that it complies with the required standards other than the operations.

Operation mode	Input					Output		
	Mode select switch	Emergency stop button	Safety door	Enable switch	MPRDY	AUTO mode	E-STOPRDY	Contactor
AUTO mode outside safety enclosure	Input a:Close Input b:Open	Open	–	–	–	ON	OFF	OFF
		Close	Open	–	–		OFF	OFF
			Close	–	–		ON	OFF
				–	OFF			OFF
				–	ON			ON
MANUAL mode inside safety enclosure	Input a:Open Input b:Close	Open	–	–	–	OFF	OFF	OFF
		Close	Close	–	–		OFF	OFF
			Open	Open	–		OFF	OFF
				Close	OFF		ON	OFF
					ON			ON

1. Emergency stop operation

When the emergency stop button is pressed, the controller main power (motor drive power) is shut down.
When the emergency stop button is pressed, the category 0 emergency stop is activated regardless of other switch settings.

2. Each mode operation by mode select switch setting

2.1 AUTO mode (Mode select switch setting, input a: Close, input b: Open)

PBX-E enable switch is disabled. The contactor turns on to supply the main power (motor drive power) to the controller only when all conditions shown below are satisfied.

Conditions

- The emergency stop button is closed.
- The safety door is closed.
- The MP RDY signal is on. (Output from the controller when the controller main power is ready to turn on.)

CAUTION

Connect the PBX terminator or PBX-E to the PB connector on the controller front panel. If the PB connector on the controller front panel is open, an emergency stop occurs.

2.2 MANUAL mode (Mode select switch setting, input a: Open, input b: Close)

PBX-E enable switch is enabled. The contactor turns on to supply the main power (motor drive power) to the controller only when all conditions shown below are satisfied.

Conditions

- The emergency stop button is closed.
- The safety door is opened.
- The enable switch of the pendant is closed (intermediate position).
- The MP RDY signal is on. (Output from the controller when the controller main power is ready to turn on.)

CAUTION

Always disconnect the PBX terminator from the PB connector on the controller front panel and connect the PBX-E to the PB connector.

3.3 Circuit examples for the RCX240

The following shows safety circuit configuration examples for the RCX240.
Customers should install the appropriate safety measures for their system by referring to these safety circuit configuration examples in order to use the robots more safely.

The following shows an example with input/output signals described below.

Input	Operation mode switch, door switch, external emergency stop, RPB-E emergency stop, RPB-E enable, MPRDY
Output	Contactor, E-STOPRDY

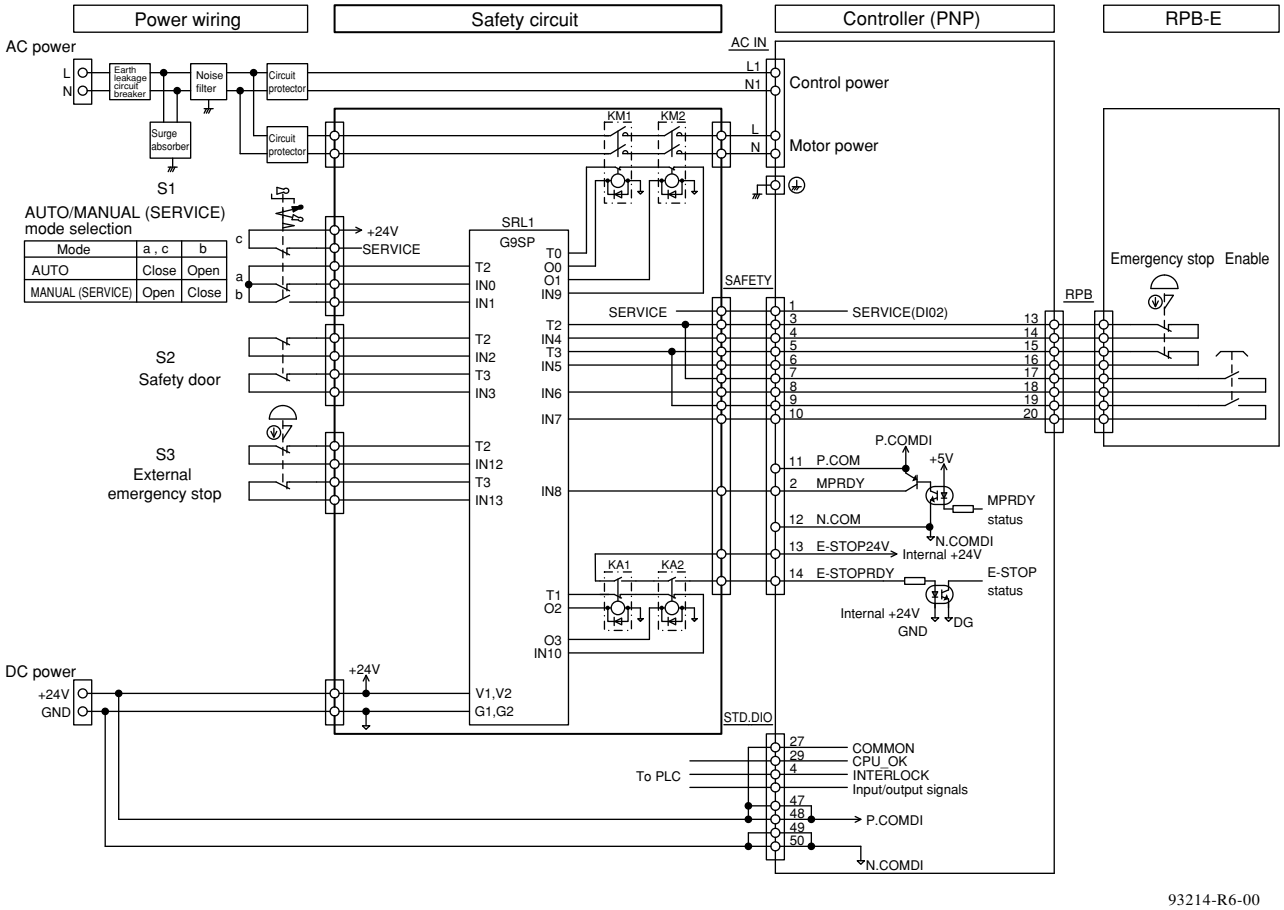
CAUTION

The controller status output signals of the parallel I/O and serial I/O, such as alarm signals, should be monitored by the host device.

3.3.1 Category 3

A safety circuit configuration example of category 3 is shown below.

Category 3 safety circuit example



Parts list

Circuit No.	Part name	Type No.	Manufacturer
S1	Key selector switch	A22TK series	OMRON
S2	Safety door switch	D4 series	OMRON
S3	Emergency stop button	A22E series	OMRON
KM1, 2	Contactor (mirror contact)	3RT2018-1FB42	SIEMENS
KA1,2	Safety relay	G7SA-3A1B	OMRON
	Socket for safety relay	P7SA-10F-ND	OMRON
SRL1	Safety controller	G9SP series	OMRON

3.3.2 Overview of circuit operation

This section describes an overview of the circuit operation for each safety circuit configuration example shown in the previous sections.

The safety controller is programmed so that the operation is performed in the table below.
Additionally, the safety controller is programmed so that it complies with the required standards other than the operations.

Operation mode	Input					Output	
	Mode select switch	Emergency stop button	Safety door	Enable switch	MPRDY	E-STOPRDY	Contactor
AUTO mode outside safety enclosure	Input a,c:Close Input b: Open	Open	–	–	–	OFF	OFF
		Close	Open	–	–	OFF	OFF
			Close	–	–	ON	OFF
				–	OFF		OFF
				–	ON		ON
MANUAL (SERVICE) mode inside safety enclosure	Input a,c:Open Input b: Close	Open	–	–	–	OFF	OFF
		Close	Close	–	–	OFF	OFF
			Close	Open	–	OFF	OFF
				Close	OFF	ON	OFF
					ON		ON

1. Emergency stop operation

When the emergency stop button is pressed, the controller main power (motor drive power) is shut down.
When the emergency stop button is pressed, the category 0 emergency stop is activated regardless of other switch settings.

2. Each mode operation by mode select switch setting

2.1 AUTO mode (Mode select switch setting, input a,c: Close, input b: Open)

RPB-E enable switch is disabled. The contactor turns on to supply the main power (motor drive power) to the controller only when all conditions shown below are satisfied.

Conditions

- The emergency stop button is closed.
- The safety door is closed.
- The MP RDY signal is on. (Output from the controller when the controller main power is ready to turn on.)

CAUTION

Connect the RPB terminator or RPB-E to the RPB connector on the controller front panel. If the RPB connector on the controller front panel is open, an emergency stop occurs.

2.2 MANUAL (SERVICE) mode (Mode select switch setting, input a,c: Open, input b: Close)

RPB-E enable switch is enabled. The contactor turns on to supply the main power (motor drive power) to the controller only when all conditions shown below are satisfied.

Conditions

- The emergency stop button is closed.
- The safety door is opened.
- RPB-E enable switch is closed (intermediate position).
- The MP RDY signal is on. (Output from the controller when the controller main power is ready to turn on.)

CAUTION

Always disconnect the RPB terminator from the RPB connector on the controller front panel and connect the RPB-E to the RPB connector.

3.4 Circuit examples for the RCX221/RCX222

The following shows category-specific safety circuit configuration examples for the RCX221/RCX222. Customers should install the appropriate safety measures for their system by referring to these safety circuit configuration examples in order to use the robots more safely.

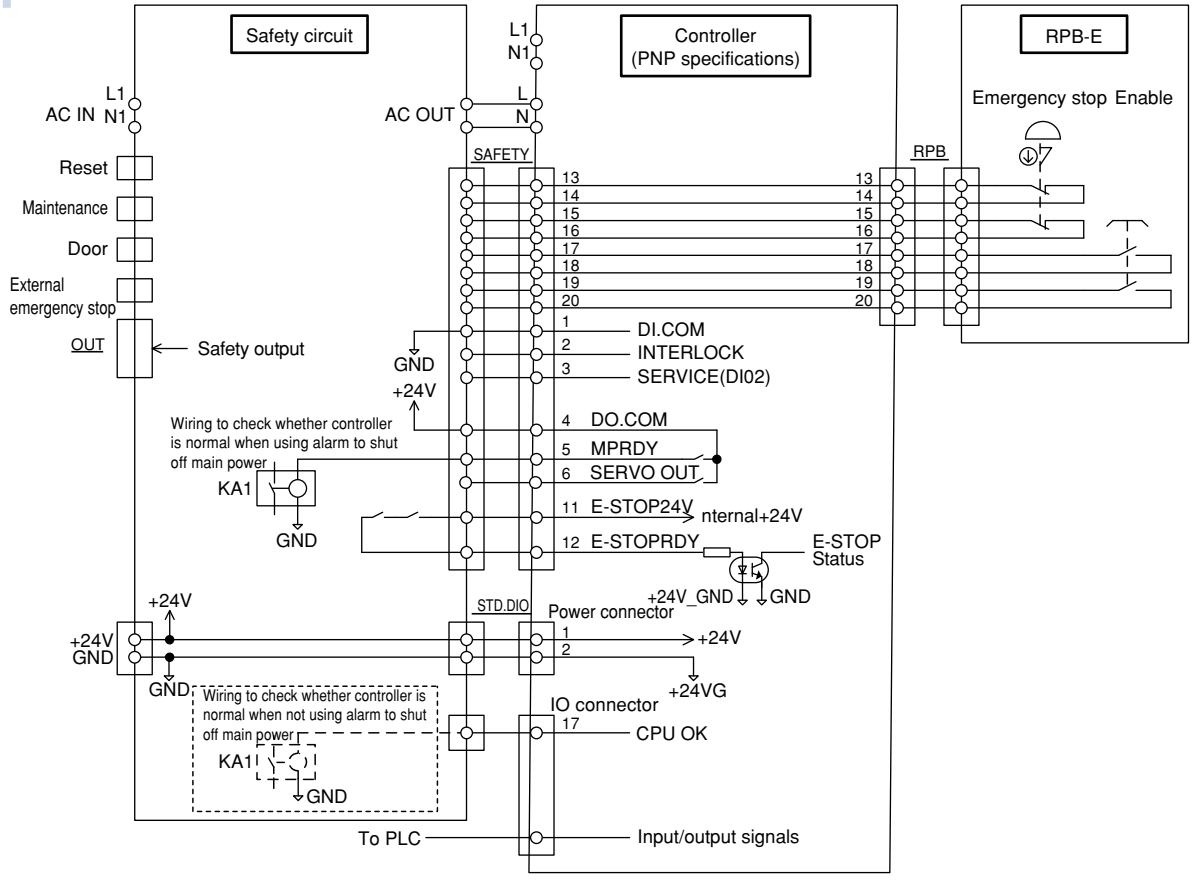
The example shown here provide the following input/output signals.

Input	Reset switch, maintenance mode switch, door switch, and external emergency stop
Output	Programming box emergency stop output and enable output

CAUTION

The controller status output signals of the parallel I/O and serial I/O, such as alarm signals, should be monitored by the host device.

Overall connection diagram (with enable switch)



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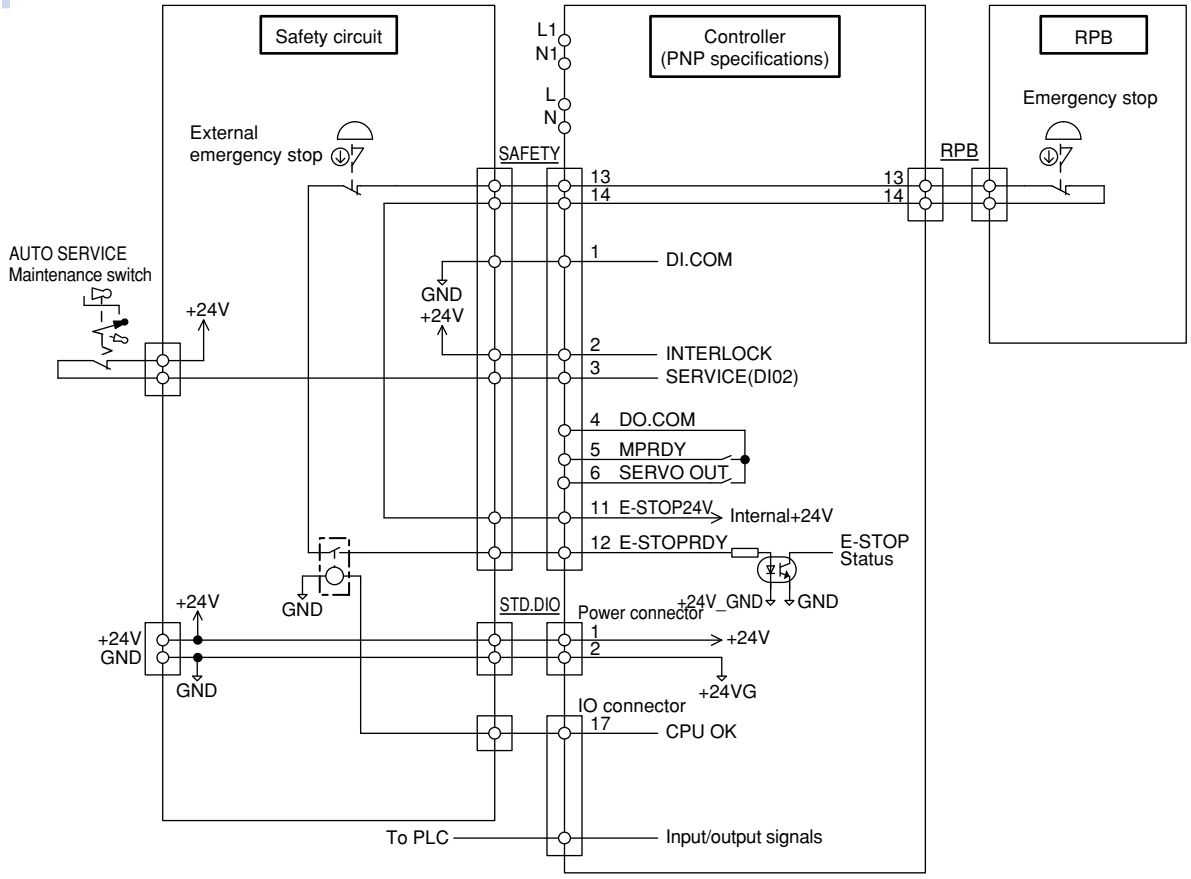
Reference: Connection diagram without enable switch (category B)

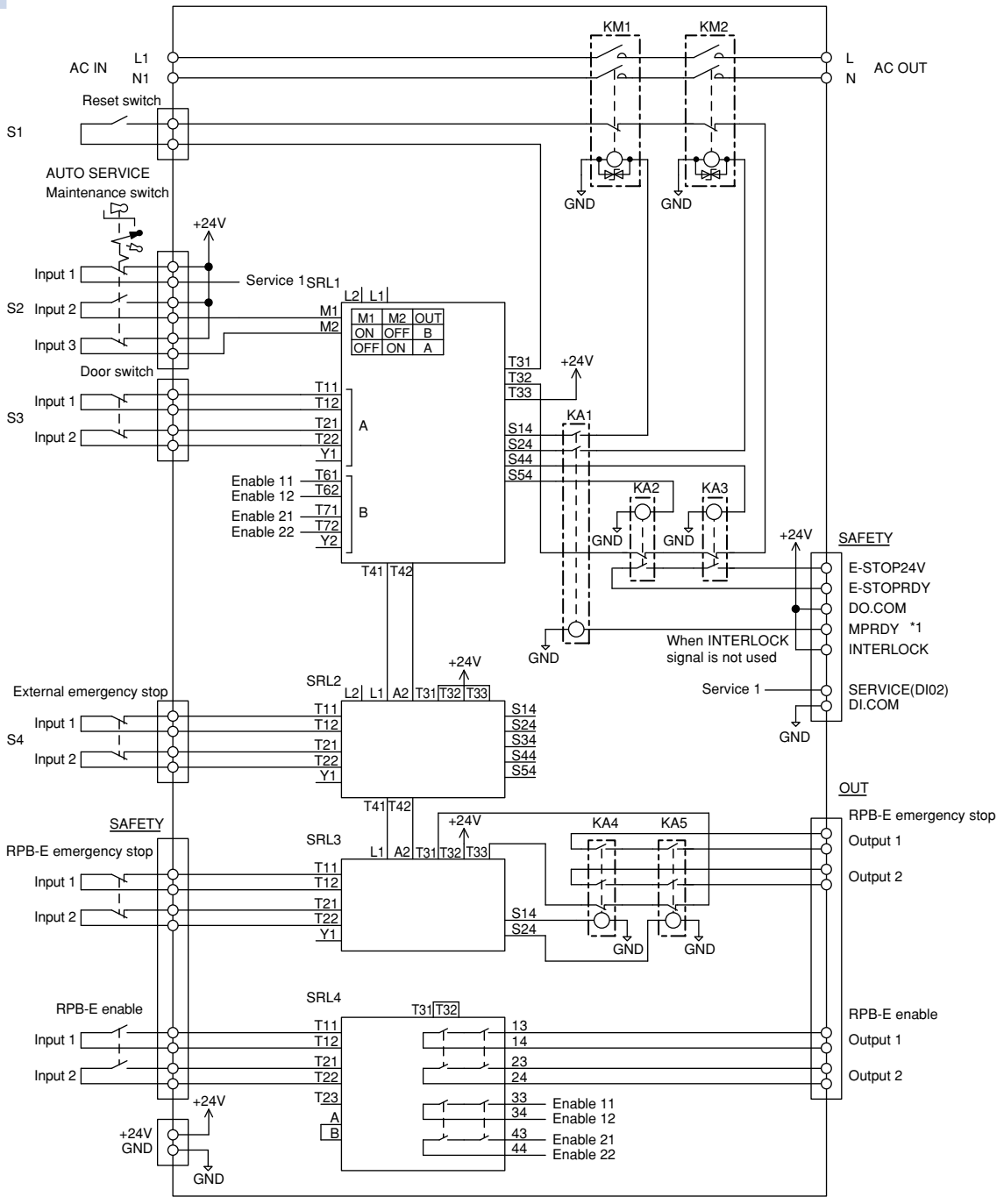


93210-R1-00

3.4.1 Category 4

A safety circuit configuration example of category 4 is shown below.

Category 4 safety circuit example



*1: Wiring to check whether the controller is normal when using an alarm to shut off the main power

93211-R1-00

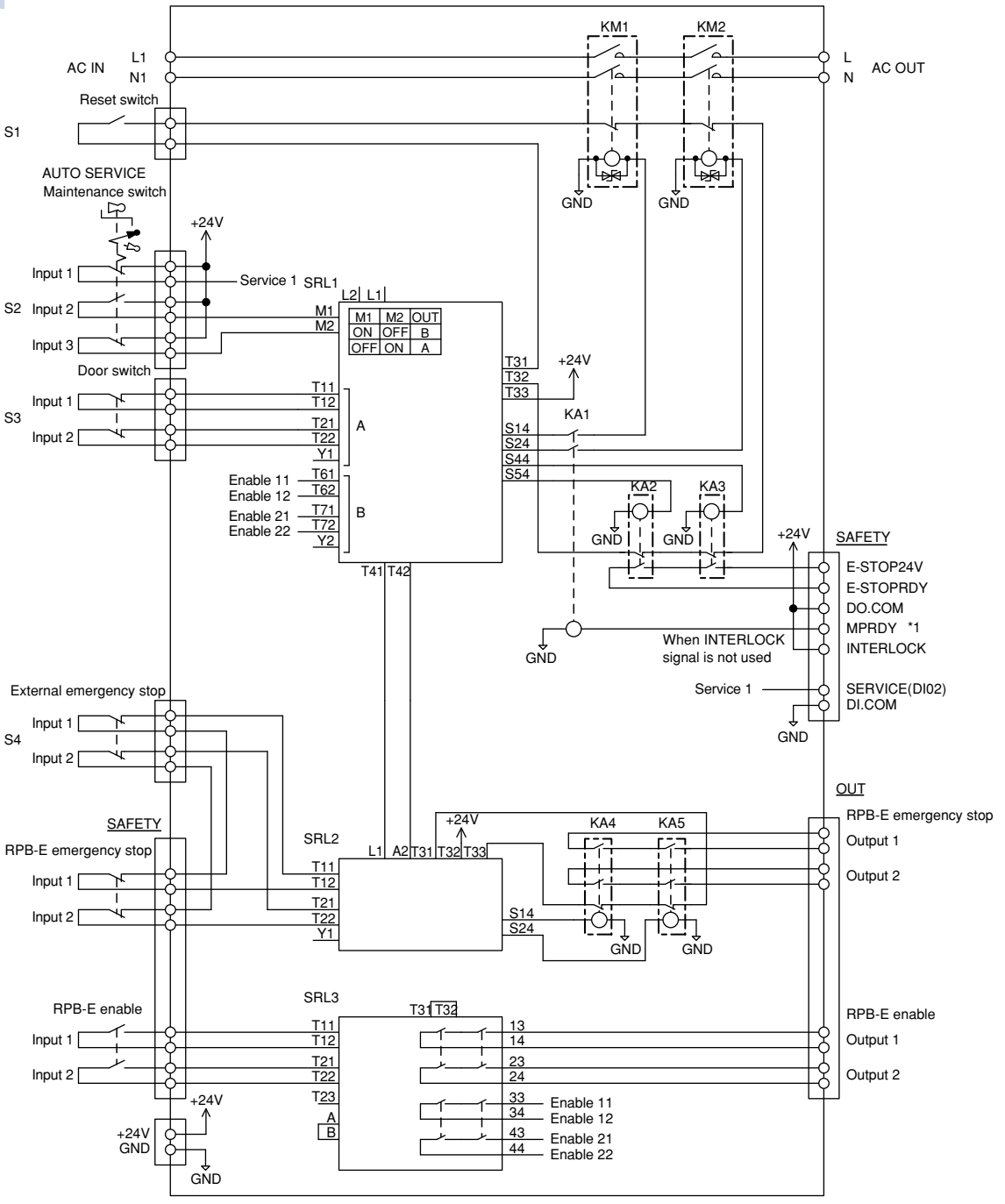
Parts list

Circuit No.	Part name	Type No.	Manufacturer
S1	Reset switch	A22 series	OMRON
S2	Key selector switch	A22 TK series	OMRON
S3	Safety door switch	D4 series	OMRON
S4	Emergency stop button	A22E series	OMRON
KM1, 2	Contactor (mirror contact)	LC1-D18	Schneider Electric
KA1 to 5	Safety relay	G7SA-3A1B	OMRON
	Socket for safety relay	P7SA-10F-ND	OMRON
SRL1	Safety relay unit	G9SX-GS226	OMRON
SRL2	Safety relay unit	G9SX-AD322	OMRON
SRL3	Safety relay unit	G9SX-BC202	OMRON
SRL4	Safety relay unit	G9SA-501	OMRON

3.4.2 Category 3

A safety circuit configuration example of category 3 is shown below.

Category 3 safety circuit example



*1: Wiring to check whether the controller is normal when using an alarm to shut off the main power

93212-R1-00

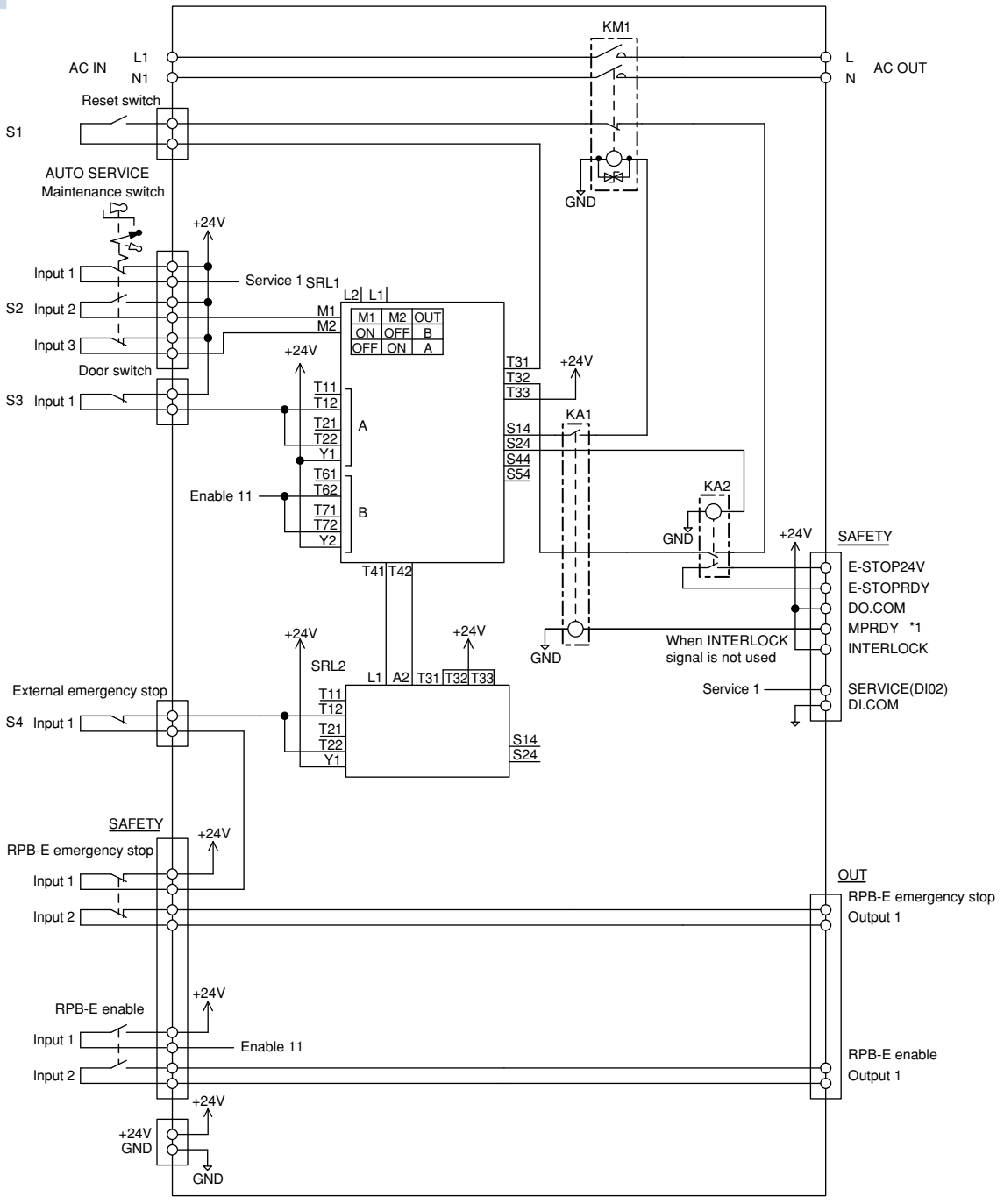
Parts list

Circuit No.	Part name	Type No.	Manufacturer
S1	Reset switch	A22 series	OMRON
S2	Key selector switch	A22 TK series	OMRON
S3	Safety door switch	D4 series	OMRON
S4	Emergency stop button	A22E series	OMRON
KM1, 2	Contactor (mirror contact)	LC1-D18	Schneider Electric
KA1 to 5	Safety relay	G7SA-3A1B	OMRON
	Socket for safety relay	P7SA-10F-ND	OMRON
SRL1	Safety relay unit	G9SX-GS226	OMRON
SRL2	Safety relay unit	G9SX-BC202	OMRON
SRL3	Safety relay unit	G9SA-501	OMRON

3.4.3 Category 2

A safety circuit configuration example of category 2 is shown below.

Category 2 safety circuit example



*1: Wiring to check whether the controller is normal when using an alarm to shut off the main power

93213-R1-00

Parts list

Circuit No.	Part name	Type No.	Manufacturer
S1	Reset switch	A22 series	OMRON
S2	Key selector switch	A22 TK series	OMRON
S3	Safety door switch	D4 series	OMRON
S4	Emergency stop button	A22E series	OMRON
KM1	Contactor (mirror contact)	LC1-D18	Schneider Electric
KA1, 2	Safety relay	G7SA-3A1B	OMRON
	Socket for safety relay	P7SA-10F-ND	OMRON
SRL1	Safety relay unit	G9SX-GS226	OMRON
SRL2	Safety relay unit	G9SX-BC202	OMRON

3.4.4 Overview of circuit operation

This section describes an overview of the circuit operation for each safety circuit configuration example shown in the previous sections.

1. During AUTO mode

The main power is supplied only when the enable switch is disabled, the controller is in a normal state (MPRDY is ON) with no internal alarms occurring, and also all the following conditions are met:

Conditions

- Maintenance mode switch is in AUTO (M1: open, M2: closed)
- Door switch's NC contact is closed.
- External emergency stop button's NC contact is closed.
- RPB-E emergency stop button's NC contact is closed.

CAUTION

Connect the RPB terminator or RPB-E to the RPB connector on the controller front panel. If the RPB connector on the controller front panel is open, an emergency stop occurs.

2. During maintenance

The main power is supplied only when the door switch is disabled, the controller is in a normal state (MPRDY is ON) with no internal alarms occurring, and also all the following conditions are met:

Conditions

- Maintenance mode switch is in SERVICE (M1: closed, M2: open)
- External emergency stop button's NC contact is closed.
- RPB-E emergency stop button's NC contact is closed.
- RPB-E enable switch's NO contact is closed.

CAUTION

Always disconnect the RPB terminator from the RPB connector on the controller front panel and connect the RPB-E to the RPB connector.

Chapter 3 SR1 series

Contents

1. System overview 3-1

1.1 System overview 3-1

1.1.1 Main system configuration 3-1

1.2 Control system configuration 3-2

1.2.1 Basic configuration 3-2

1.2.2 Power supply and emergency stop system circuit configuration 3-3

1.3 Programming box (HPB-D) 3-4

1.3.1 Part names and functions 3-4

1.3.2 HPB connector and HPB-D SAFETY connector 3-5

1.4 SERVICE mode 3-6

1.4.1 What is SERVICE mode? 3-6

1.4.2 Flow for enabling the SERVICE mode functions 3-6

1.4.3 Limiting functions in SERVICE mode 3-7

2. EMC countermeasure examples 3-8

2.1 SR1 3-8

2.1.1 Configuration 3-8

2.1.2 Countermeasure components 3-9

3. External safety circuit examples 3-12

3.1 Safety requirements 3-12

3.1.1 CE marking 3-12

3.2 Circuit examples for the SR1 3-13

3.2.1 Category 4 3-15

3.2.2 Category 3 3-16

3.2.3 Category 2 3-17

3.2.4 Overview of circuit operation 3-18

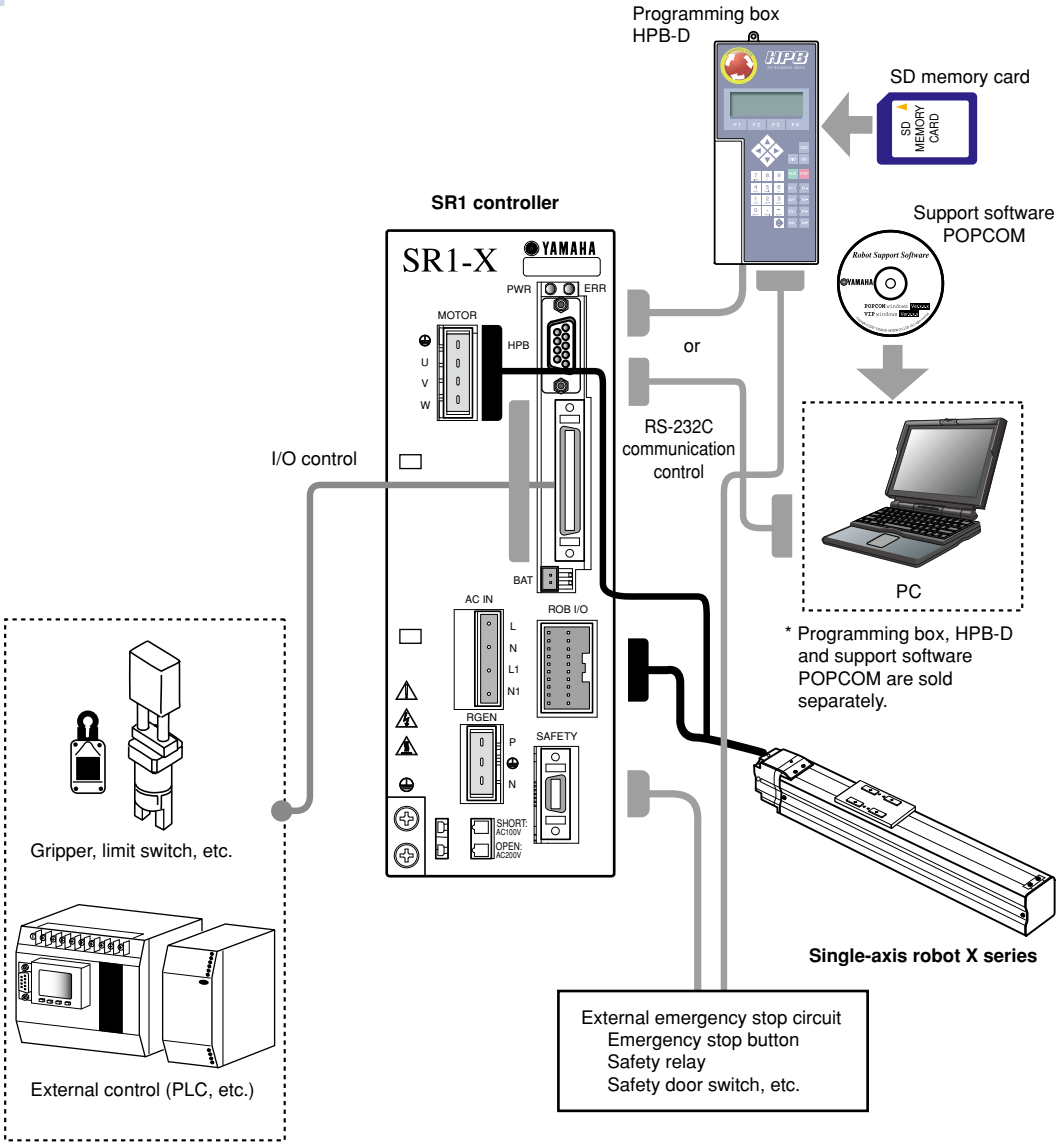
1. System overview

1.1 System overview

1.1.1 Main system configuration

■ SR1

System for controlling one robot



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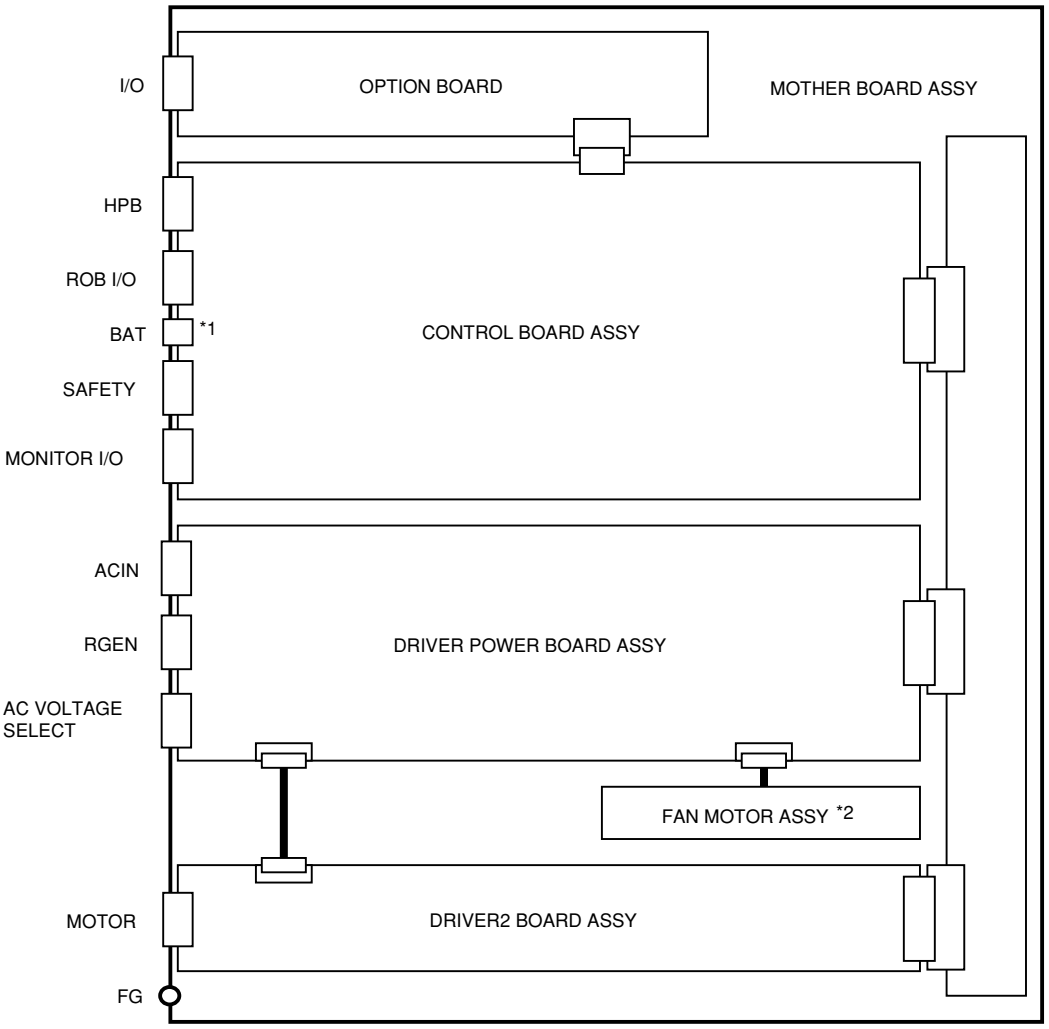
1.2 Control system configuration

1.2.1 Basic configuration

The basic block diagram of the SR1 robot controller system is shown below.

■ SR1

Basic block diagram



*1: Installed only in SR1-X
*2: Installed only in SR1-X-20 and SR1-P-20

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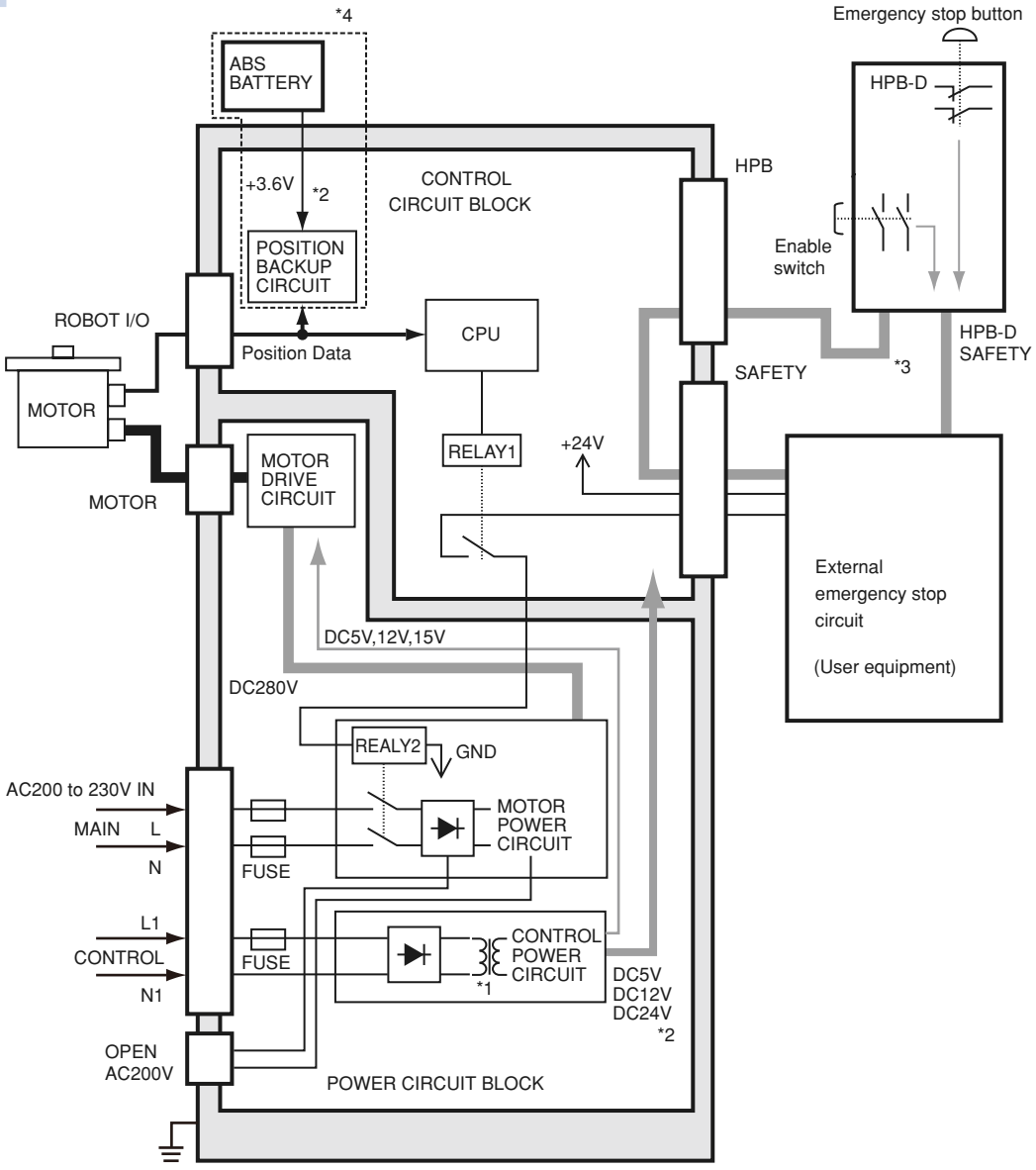
1.2.2 Power supply and emergency stop system circuit configuration

The control system's power supply system and emergency stop system circuit block diagram are shown below.

Power supply and emergency stop circuit block diagram



*1) The input power and each control power are insulated by the insulated transformer.

*2) The 0V line for the 3.6VDC, 5VDC, 12VDC and 24VDC is not connected to the protective earth.

*3) Refer to the HPB-D connector input/output signal table for the wiring diagram from the HPB-D.

*4) Excluding SR1-P.

93303-Q6-00

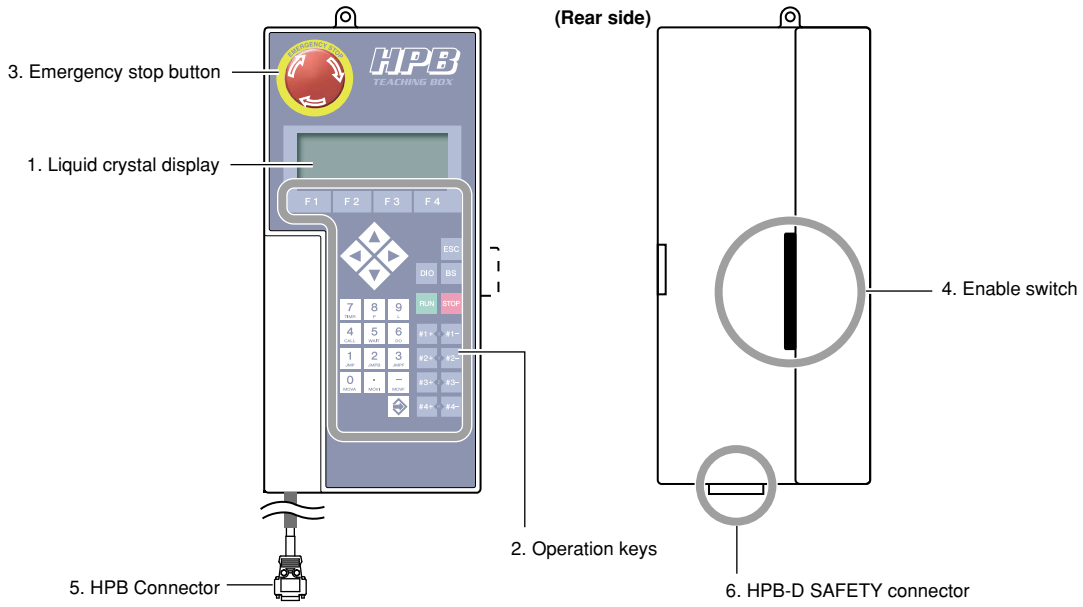
1.3 Programming box (HPB-D)

The programming box (HPB-D) is a hand-held unit specifically designed to connect to the controller, in order to perform various operations. The HPB-D allows all operations including manual operation of the robot, programming and editing, teaching, and parameter setting.

1.3.1 Part names and functions

The HPB-D has an emergency stop button and an enable switch. The contact outputs of these can be used to connect to the emergency stop circuit of the entire equipment via the SAFETY connector on the bottom of the HPB-D.

HPB-D



● Main Functions

No.	Part name	Function
1	Liquid crystal display	This is a liquid crystal display (LCD) with 20 characters × 4 lines, showing various types of information.
2	Operation keys	These keys are used to operate a robot or input programs. The keys are divided into 2 main groups: function keys and data entry/operation keys.
3	Emergency stop button	Pressing this button during operation immediately stops robot movement. This is a contact B (normally closed) type switch. The A165E-S-02 made by OMRON is used.
4	Enable switch	This is a 3-position switch designed in consideration of safety. Pressing this switch to the middle position only enables robot operation. This switch is disabled when LOCKIN1 to 4 in the HPB-D SAFETY connector are not wired. Configure an external safety circuit so that the state of this switch determines the robot operating state as follows: Switch released : Emergency stop state Switch in middle position : Operable state Switch pressed : Emergency stop state The A4E-B200HS made by OMRON is used.
5	HPB connector	Use this connector to connect the HPB programming box to the robot controller.
6	HPB-D SAFETY connector	The contact outputs of the emergency stop button and enable switch are connected. Attaching the supplied 15-pin D-sub connector (female) directly to this safety connector enables the emergency stop button only.

1.3.2 HPB connector and HPB-D SAFETY connector

The HPB-D has an emergency stop button and an enable switch. The contact outputs of these can be used to connect to the emergency stop circuit of the entire equipment via the SAFETY connector on the controller and the HPB-D SAFETY connector.
This section describes signal connections.

CAUTION

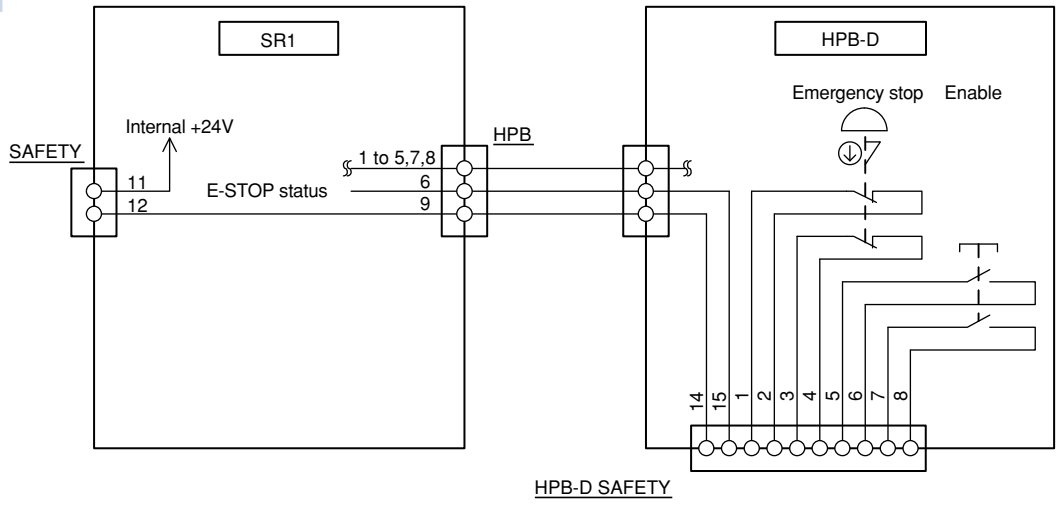
- **Do not change or modify the cable and connector. In addition to the input/output signals for controlling the programming box, the HPB connector and HPB-D SAFETY connector include signals used to configure an external safety circuit, and so changing or modifying the cable and connector is very dangerous.**
- **Always configure an external safety circuit by using the SAFETY connector on the controller and the HPB-D SAFETY connector.**

Pin to pin connections are as follows:

SR1		Controller internal connection	HPB-D		
SAFETY connector			HPB connector		Remarks
Name	Pin No.		Pin No.	Name	
EMG1	11	Internal +24V	-	-	
EMG2	12	1 to 1	9		Internally connected to pin 14 in SAFETY connector
-	-	E-STOP status circuit input	6		Internally connected to pin 15 in SAFETY connector

	SAFETY connector		Remarks
	Pin No.	Name	
	1	E-STOPIN1	Emergency stop contact: Line 1
	2	E-STOPIN2	
	3	E-STOPIN3	Emergency stop contact: Line 2
	4	E-STOPIN4	
	5	LCKIN1	Enable contact: Line 1
	6	LCKIN2	
	7	LCKIN3	Enable contact: Line 2
	8	LCKIN4	
	14	HPB EMG2	Internally connected to pin 9 in HPB connector
	15	HPB EMG1	Internally connected to pin 6 in HPB connector

Circuit diagram



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1.4 SERVICE mode

This section describes SERVICE mode.

1.4.1 What is SERVICE mode?

SERVICE mode is used to perform work using the HPB-D within the safety enclosure of the robot system.

To use the SERVICE mode function, it must be enabled. The SERVICE mode can be enabled or disabled by selecting the HPB-D menu or by using PRM372 (Service mode enable parameter).
When the SERVICE mode function is enabled, the controller constantly monitors whether SERVICE mode is entered. When the SERVICE mode input (SVCE) contact is open (OFF), the controller is in SERVICE mode.
If a serial I/O unit is installed, SERVICE mode is entered when either one of the SAFETY connector SVCE contact or the serial I/O SVCE contact is open (OFF). (This means that only when both SAFETY connector SVCE contact and serial I/O SVCE contact are closed (ON), the controller is not in SERVICE mode.)

In the SERVICE mode, the following limiting functions will work.

● **Limiting functions that work in "SERVICE mode"**

- Limits command input from any device other than HPB-D.
- Limits robot movement speed.
- Prohibits automatic operation and step operation.
- Enables hold-to-run function.
  (Hold-to-run function permits the robot to move only when the HPB-D key is kept pressed.)

The limiting functions in SERVICE mode can be set individually.

WARNING

RESTRICTION ON THE ROBOT MOVING SPEED IS NOT A SAFETY-RELATED FUNCTION.
TO REDUCE THE RISK OF COLLISION BETWEEN THE ROBOT AND WORKERS, THE USER MUST TAKE THE NECESSARY PROTECTIVE MEASURES SUCH AS ENABLE DEVICES ACCORDING TO RISK ASSESSMENT BY THE USER.

NOTE

- The robot pauses when the SERVICE mode input is changed during program operation or jog movement.
- The NPN/PNP specifi cations for SVCE are determined by DI.COM and DO.COM inputs.
- The input current for SVCE should be 8mA or more.

1.4.2 Flow for enabling the SERVICE mode functions

- SERVICE mode function is enabled.

↓

- Open (turn OFF) the SVCE contact.
  If a serial I/O unit is installed, open (turn OFF) either one of the SAFETY connector SVCE contact or the serial I/O SVCE contact or both.

↓

- Limiting functions in SERVICE mode starts working.

The limiting functions in SERVICE mode can be set individually. Refer to the next section for details on the safety controls.

1.4.3 Limiting functions in SERVICE mode

The following 4 limiting functions can be set in SERVICE mode.

1. Limiting the operation devices (limiting command input from any device other than HPB-D)
2. Limiting the robot movement speed
3. Limiting the automatic operation and step operation (prohibiting the automatic operation and step operation)
4. Hold-to-Run function

Refer to the controller user's manual for how to make each setting.

WARNING

CHANGING ANY OF THE LIMITING FUNCTIONS FROM THEIR DEFAULT SETTINGS IS LIKELY TO INCREASE THE RISK TO PERSONNEL OPERATING OR MAINTAINING THE ROBOT. HOWEVER, THE USER CAN CHANGE THE SETTINGS FOR THE LIMITING FUNCTIONS ONLY IN CASES WHERE JUDGED NOT HAZARDOUS. IN THOSE CASES, TAKE EXTRA CAUTION TO ENSURE SAFETY.

1. Limiting the operation devices

Specify the devices that may be used to operate the robot.
In "SERVICE mode", only the HPB-D can be used as the robot operation device, and any command input from all other device is disabled. However, if the user wants to permit a command input from other devices even in "SERVICE mode", then the user can cancel this limiting function only in cases where judged not hazardous.

Setting	Description
0 (default)	Only command inputs from the HPB-D are permitted in "SERVICE mode".
1	Only command inputs from the HPB-D and parallel I/O are permitted in "SERVICE mode".
2	Only command inputs from the HPB-D and optional unit are permitted in "SERVICE mode".
3	Any command input is permitted even in "SERVICE mode".

2. Limiting the robot movement speed

This function limits robot moving speed.
In "SERVICE mode", robot moving speed is limited to below 3% of the maximum speed. However, if the user wants to set the robot moving speed faster than 3% even in "SERVICE mode", then the user can cancel this limiting function only in cases where judged not hazardous.

Setting	Description
0 (default)	Robot movement speed is limited to 3% of maximum speed in "SERVICE mode".
1	Robot movement speed is not limited even in "SERVICE mode".

3. Limiting the automatic operation and step operation

Determine whether to permit or prohibit the automatic operation and step operation.
In "SERVICE mode", automatic operation and step operation are prohibited and cannot be performed. However, if the user wants to permit automatic operation and step operation even in "SERVICE mode", then the user can cancel this limiting function only in cases where judged not hazardous.

Setting	Description
0 (default)	Automatic operation and step operation are prohibited in "SERVICE mode".
1	Automatic operation and step operation are permitted even in "SERVICE mode".

4. Hold-to-Run function

Determine whether to enable or disable the Hold-to-Run function.
In "SERVICE mode", the Hold-to-Run function is always enabled. However, if the user wants to disable the Hold-to-Run function even in "SERVICE mode", then the user can cancel this function only in cases where judged not hazardous.

Setting	Description
0 (default)	Hold-to-Run function is enabled in "SERVICE mode".
1	Hold-to-Run function is disabled even in "SERVICE mode".

2. EMC countermeasure examples

Regarding EMC Directive, the customer's final product (entire system) including the YAMAHA robot must provide the necessary countermeasures. We at YAMAHA determine a model for single units of YAMAHA robots (controller, robot, and peripheral device) and verify that it complies with the relevant standards of EMC Directive.
In order to ensure the customer's final product (entire system) complies with EMC Directive, the customer should take appropriate EMC countermeasures. Typical EMC countermeasures for a single unit of YAMAHA robot are shown for reference.

CAUTION

The following description and circuits are typical countermeasures used when the robot and controller are tested under YAMAHA installation conditions. When the robot and controller are used while installed in the customer's system, the actual test results may differ depending on installation conditions.

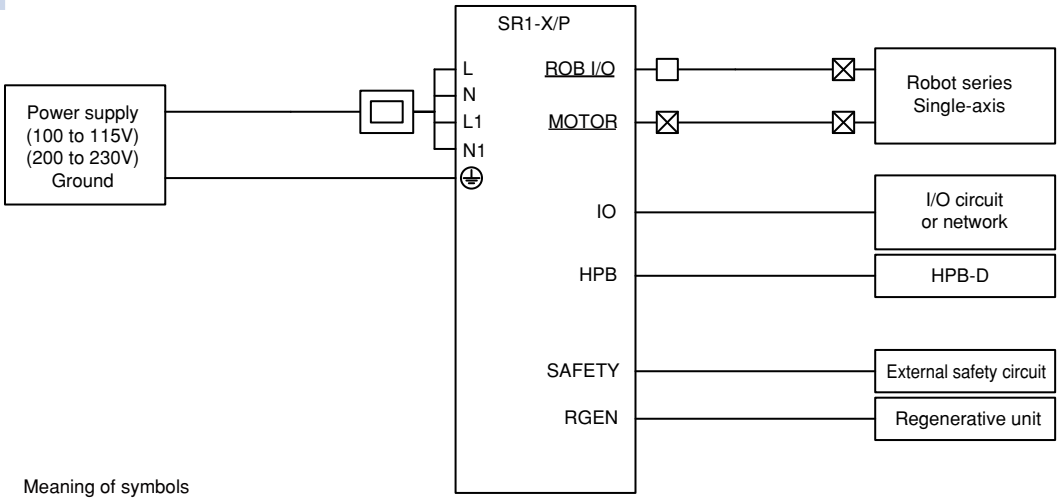
2.1 SR1

2.1.1 Configuration

CAUTION

As shown in the following figure, the ferrite cores and noise filter on the controller side should be placed as close to the controller body as possible. The ferrite cores on the robot side should be placed as close to the robot body as possible.

Typical component layout for EMC countermeasures



Meaning of symbols

: Noise filter MC1210L : TDK-Lambda Corporation
: Ferrite core ZCAT3035-1330 : TDK
: Ferrite core ZCAT2032-0930 : TDK
: Ferrite core 1 turn

93306-Q6-00

2.1.2 Countermeasure components

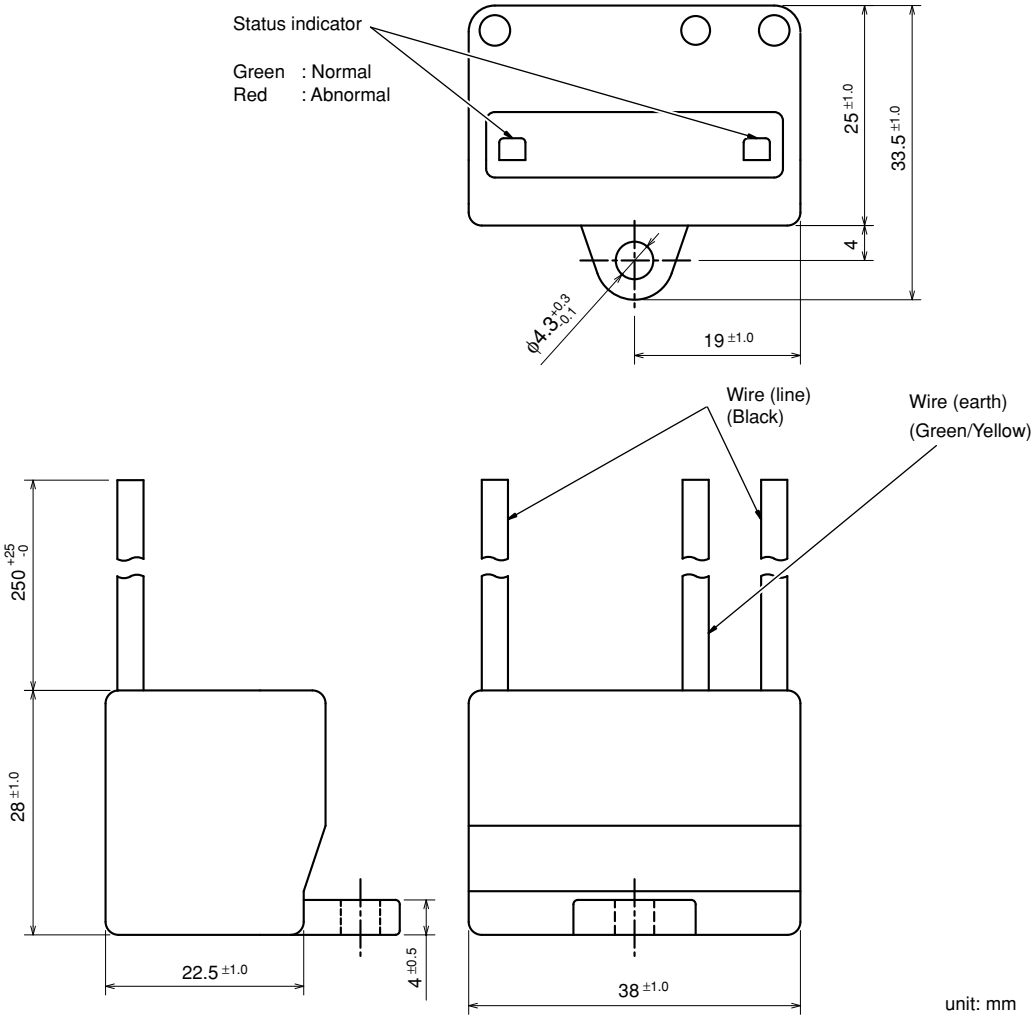
■ Surge absorber

The SR1 does not need any external surge absorber. However, to further enhance the surge resistance, install a surge absorber on the AC power line.
A recommended surge absorber is shown below.

● Recommended surge absorber

Manufacturer : SOSHIN ELECTRIC CO., LTD.
Type No. : LT-C12G801WS

Dimensional outline



93307-Q6-00

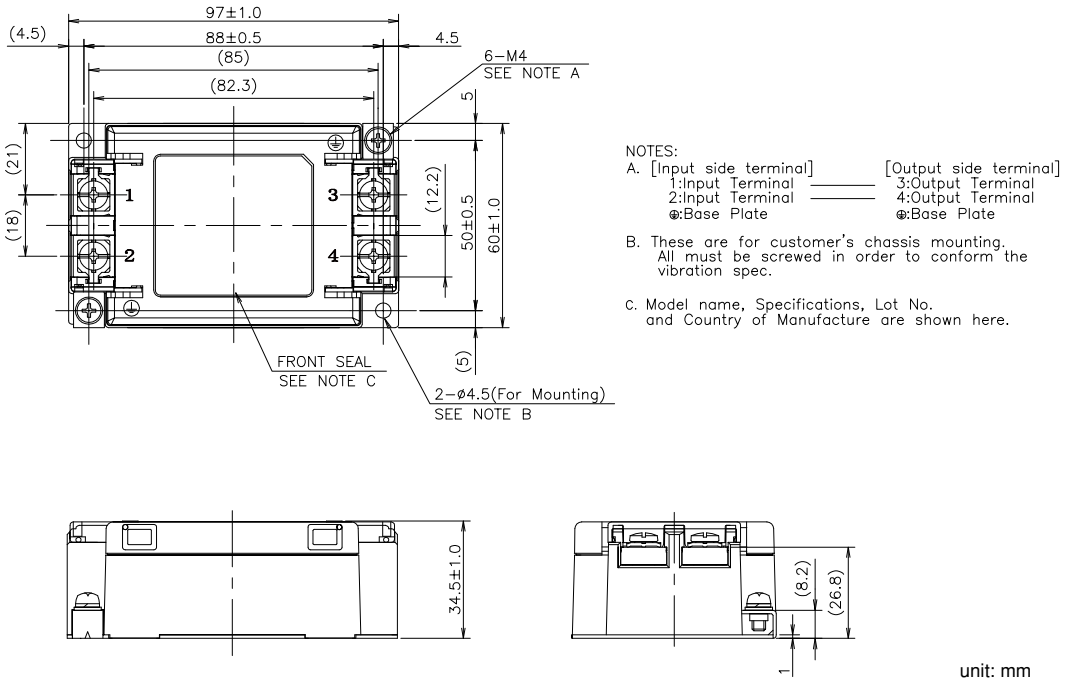
■ Noise filter

Always install an external noise filter on the AC power line.
A recommended noise filter is shown below.

● Recommended noise filter

Manufacturer : TDK-Lambda Corporation
Type No. : MC1210L

Dimensional outline



unit: mm

93308-Q6-00

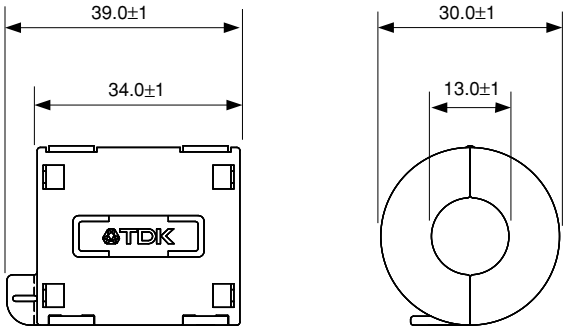
Ferrite core

Install ferrite cores according to the customer's final product (entire system).
Recommended ferrite cores are shown below.

● Recommended ferrite core 1

Manufacturer : TDK
Type No. : ZCAT3035-1330

Dimensional outline



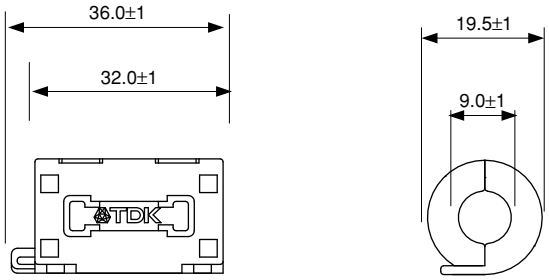
unit: mm

93309-Q6-00

● Recommended ferrite core 2

Manufacturer : TDK
Type No. : ZCAT2032-0930

Dimensional outline



unit: mm

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3. External safety circuit examples

This section describes category-specific safety circuit configuration examples using the HPB-D.
To use the robots more safely, take the appropriate safety measures by referring to the circuit examples.

3.1 Safety requirements

3.1.1 CE marking

To comply with the machinery directives, the "performance level (PL)" required of the safety circuit must be evaluated.
Performance levels (PL) are determined by the following parameters:

● **Major factors that determine performance levels**

1. Category
2. MTTFd (Mean Time To Dangerous Failure)
3. DCavg (Average Diagnostic Coverage)
4. CCF (Common Cause Failure) : Checklist score > 65 ?

(Please obtain the data on each component from the component manufacturer.)

The performance level (PL) of a safety circuit is determined by the following flow.

● **Flow for determining performance levels**

1. Determine the "performance level (PLr) required of the safety circuit" by means of risk assessment.
2. Configure the safety circuit that satisfies the requirements of the category that meets PLr.
3. Calculate the safety circuit's "performance level (PL)" from the MTTFd, DCavg, and CCF of the devices used for the safety circuit, and then make sure that the calculated PL is equal to or higher than the "performance level (PLr) required of the safety circuit" (PLr ≤ PL).

> In the customer's final system, the performance level (PLr) required of the safety circuit should be determined by means of risk assessment, and then the safety circuit with the corresponding performance level (PL) should be configured.

● **Safety parts subject to performance level calculation**

The table below shows the safety parts and B10d reference values.

CAUTION
Please obtain the latest information from the parts manufacturers.

	Parts Name	Model Name	Maker	B10d
HPB-D	Emergency stop button	A165E-S-02	OMRON	1×10^5
	Enable switch	A4E-B200HS	OMRON	1×10^5

3.2 Circuit examples for the SR1

The following shows category-specific safety circuit configuration examples for the SR1.
Customers should install the appropriate safety measures for their system by referring to these safety circuit configuration examples in order to use the robots more safely.

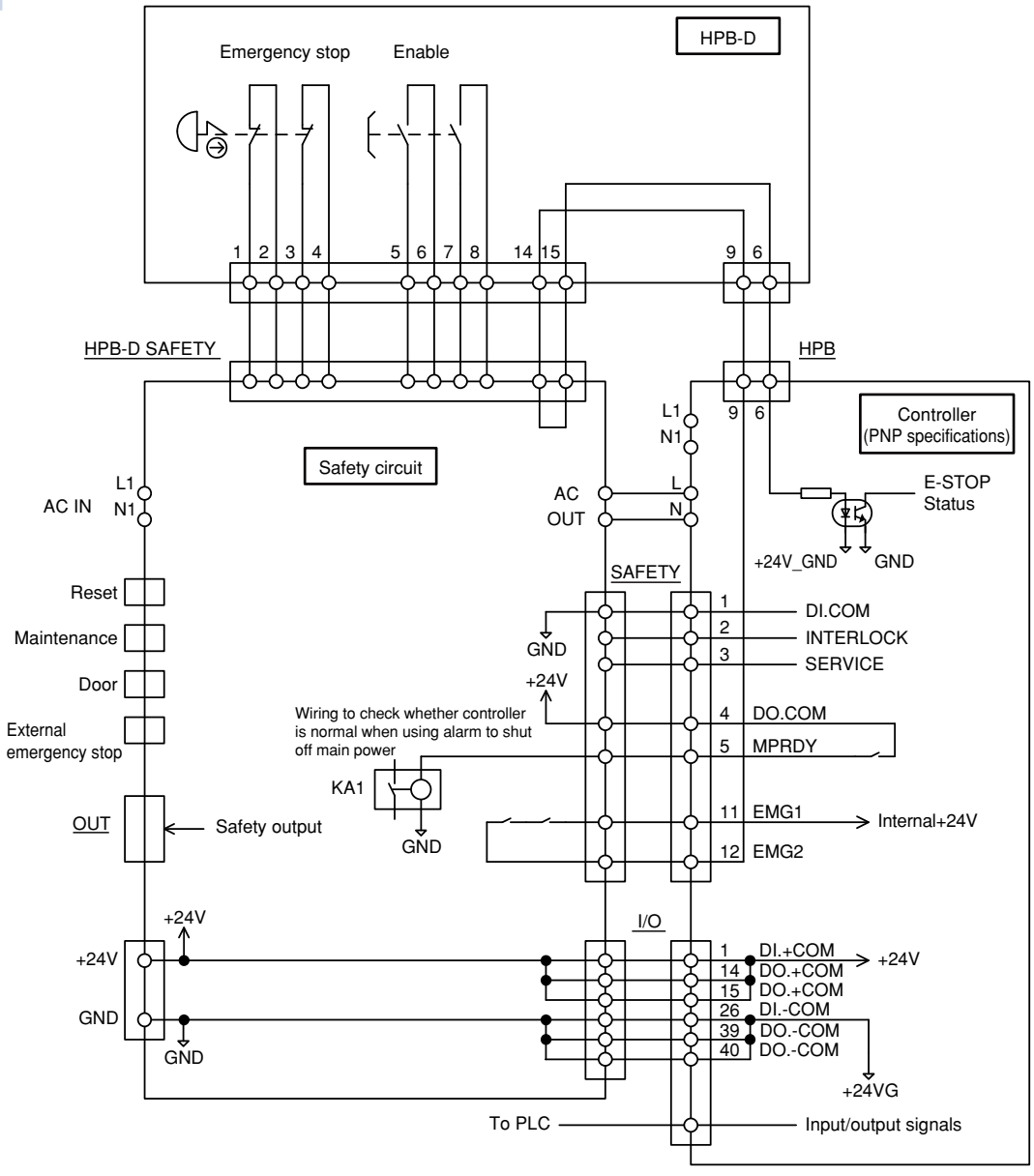
The example shown here provide the following input/output signals.

Input	Reset switch, maintenance mode switch, door switch, and external emergency stop
Output	Programming box emergency stop output and enable output

CAUTION

The controller status output signals of the parallel I/O and serial I/O, such as alarm signals, should be monitored by the host device.

Overall connection diagram (with enable switch)



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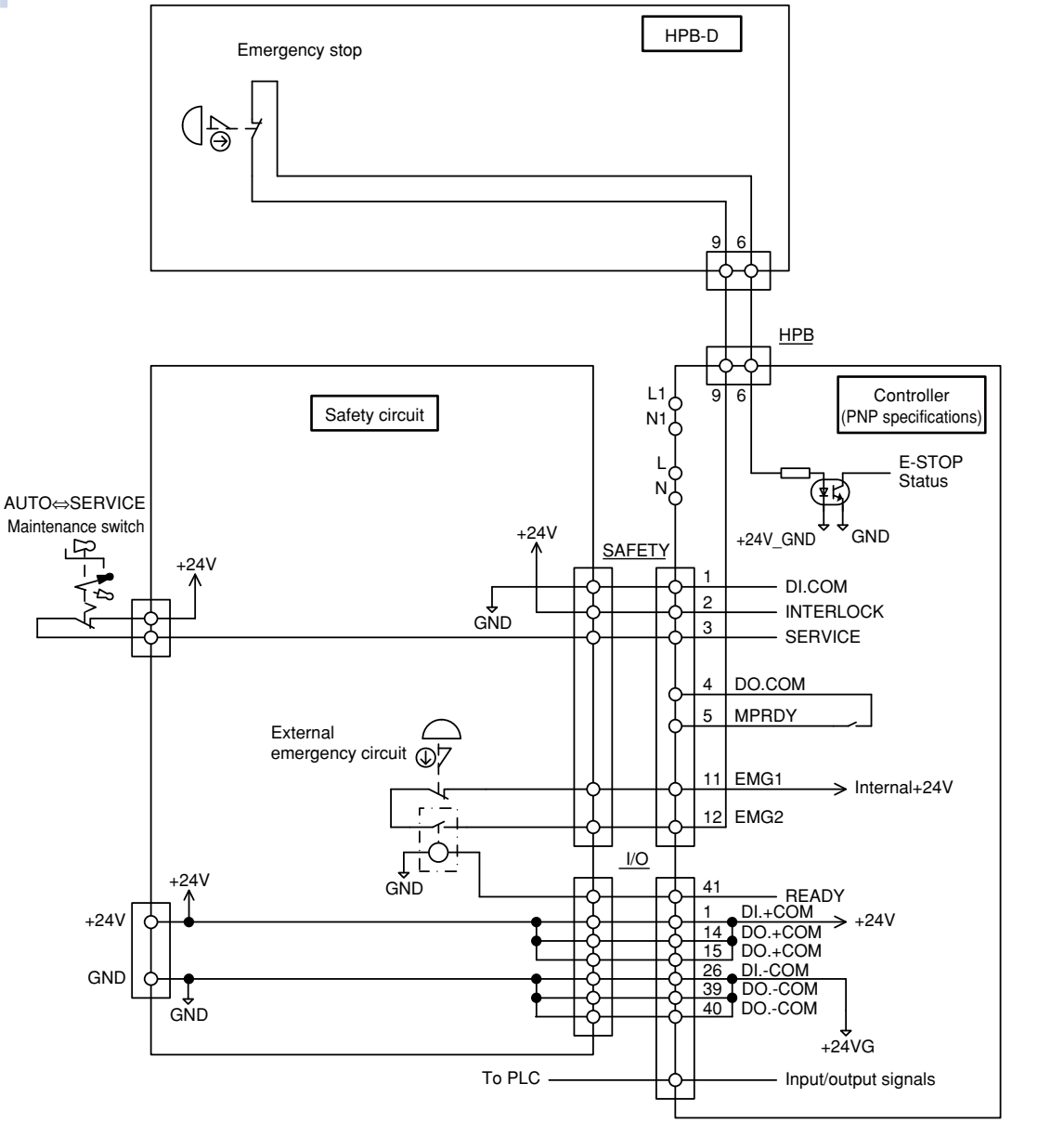
Reference: Connection diagram without enable switch (category B)

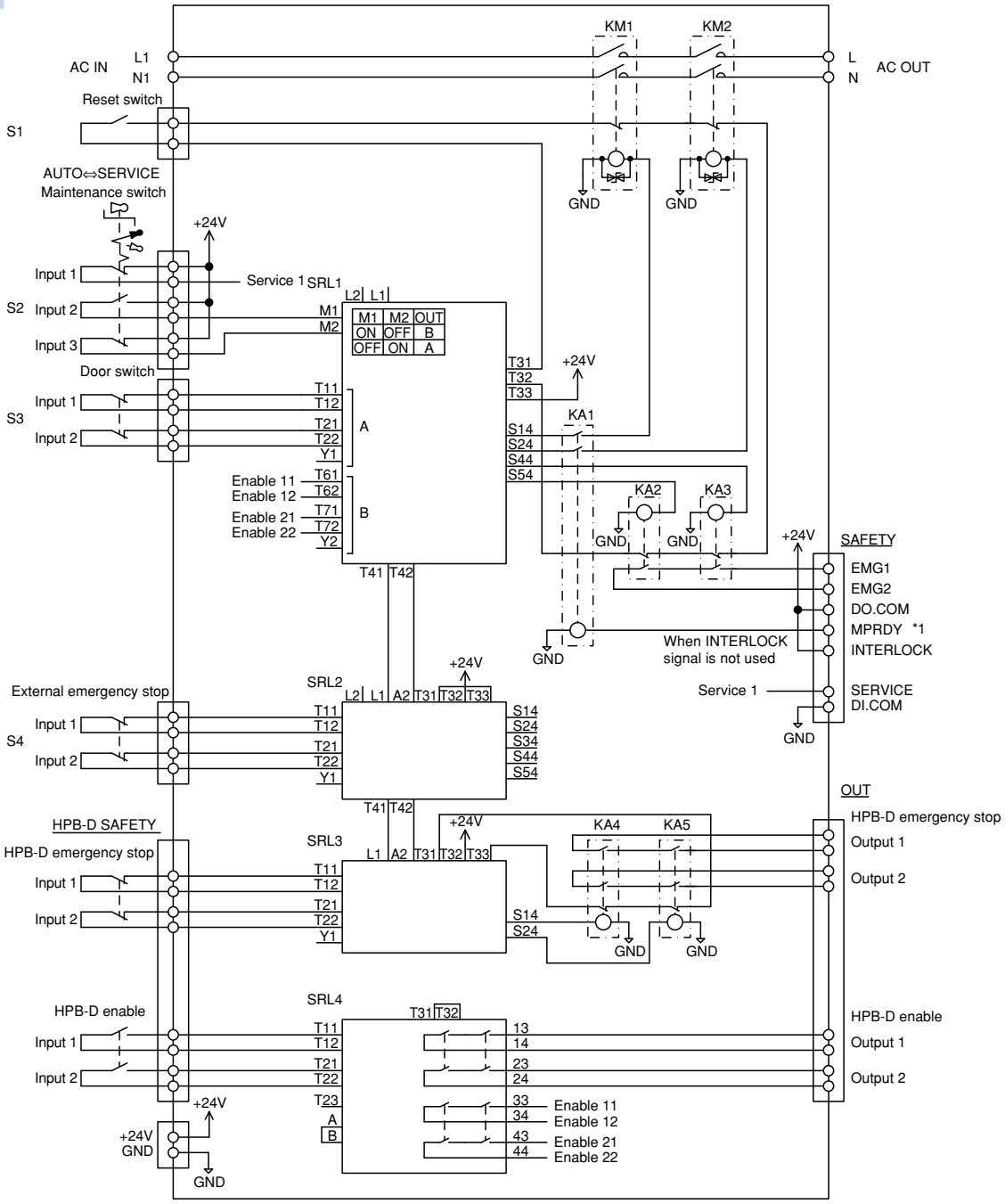


93310-Q6-00

3.2.1 Category 4

A safety circuit configuration example of category 4 is shown below.

Category 4 safety circuit example



*1: Wiring to check whether the controller is normal when using an alarm to shut off the main power

93313-Q6-00

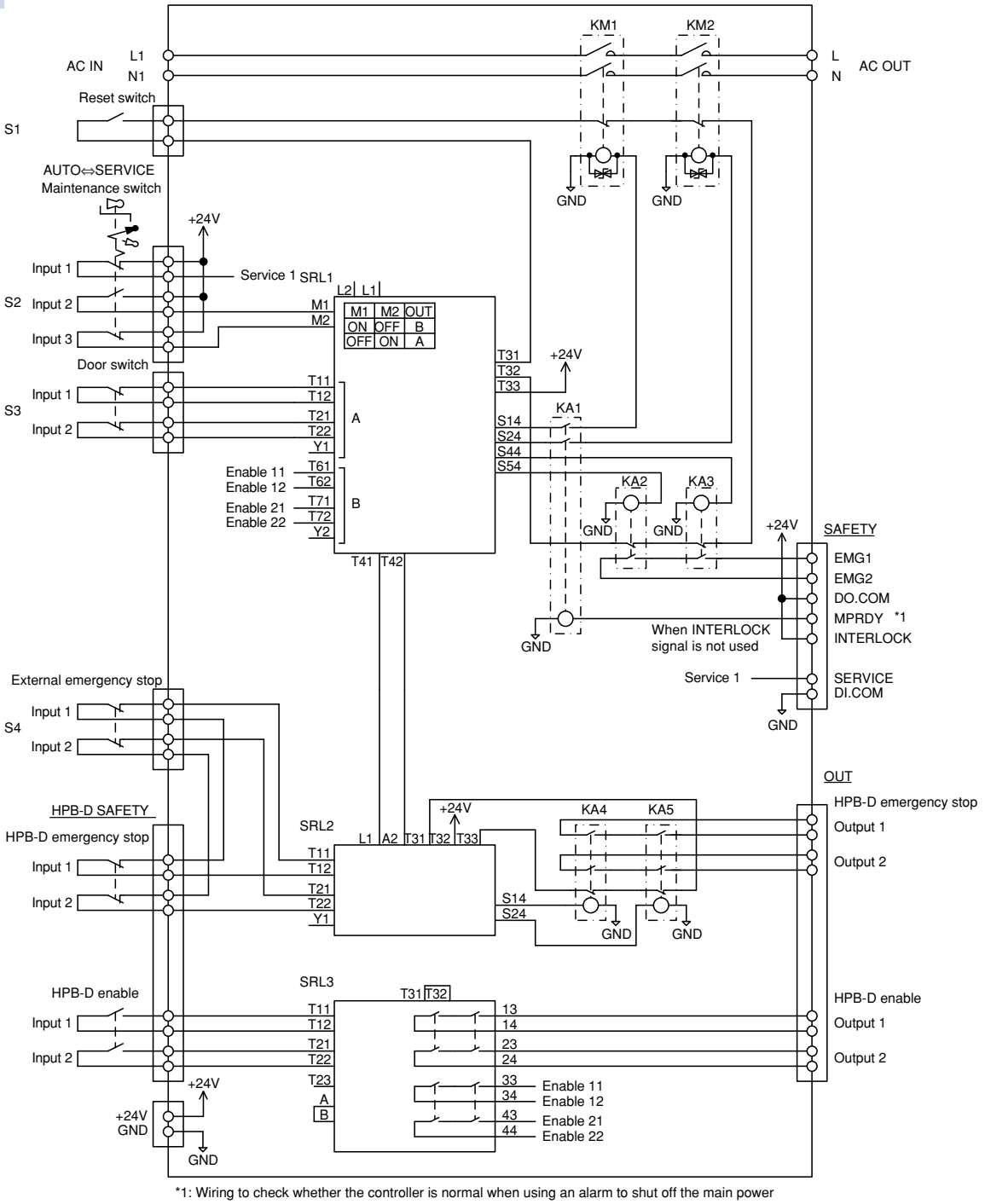
Parts list

Circuit No.	Part name	Type No.	Manufacturer
S1	Reset switch	A22 series	OMRON
S2	Key selector switch	A22 TK series	OMRON
S3	Safety door switch	D4 series	OMRON
S4	Emergency stop button	A22E series	OMRON
KM1, 2	Contactor (mirror contact)	LC1-D09	Schneider Electric
KA1 to 5	Safety relay	G7SA-3A1B	OMRON
	Socket for safety relay	P7SA-10F-ND	OMRON
SRL1	Safety relay unit	G9SX-GS226	OMRON
SRL2	Safety relay unit	G9SX-AD322	OMRON
SRL3	Safety relay unit	G9SX-BC202	OMRON
SRL4	Safety relay unit	G9SA-501	OMRON

3.2.2 Category 3

A safety circuit configuration example of category 3 is shown below.

Category 3 safety circuit example



*1: Wiring to check whether the controller is normal when using an alarm to shut off the main power

93314-Q6-00

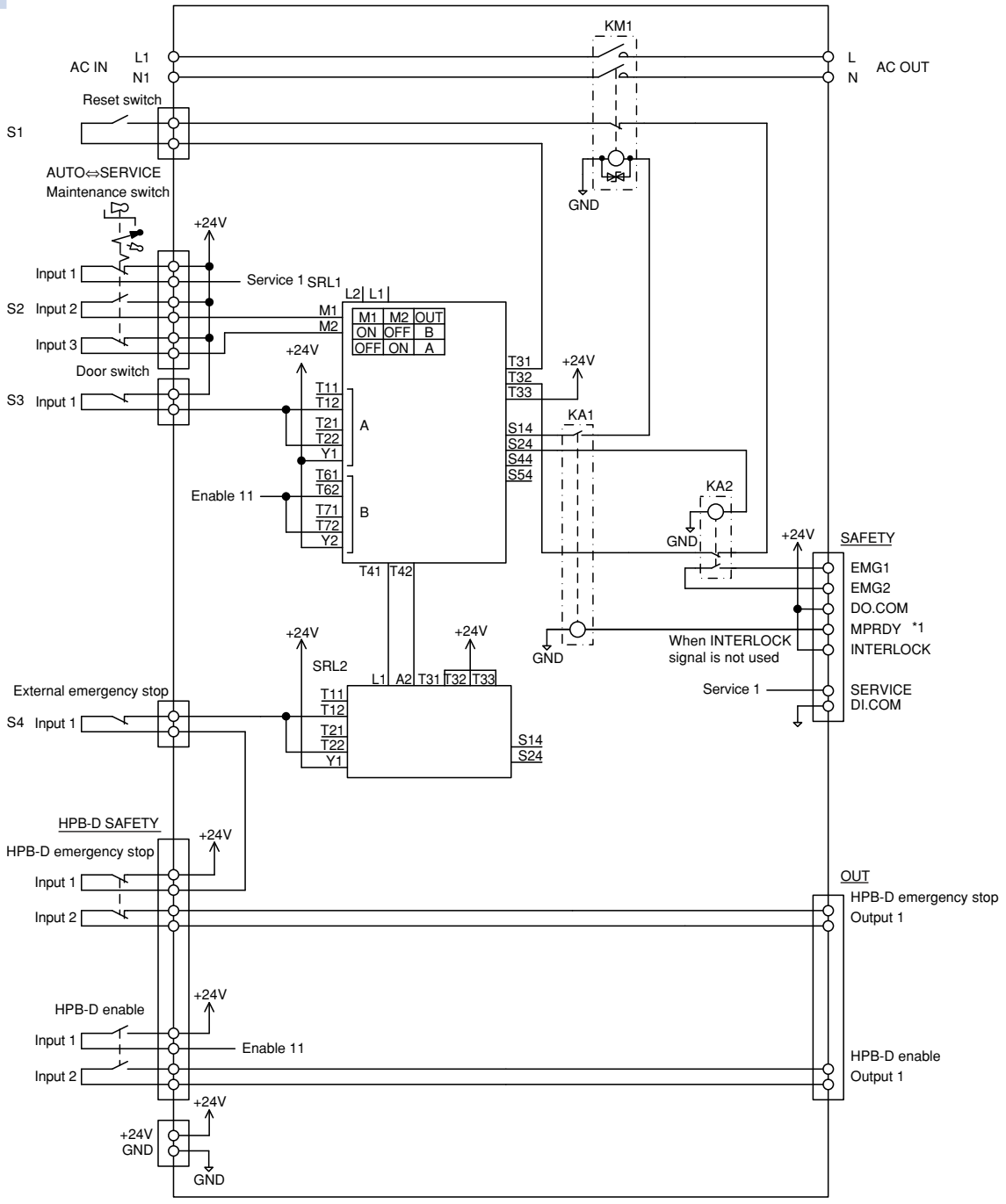
Parts list

Circuit No.	Part name	Type No.	Manufacturer
S1	Reset switch	A22 series	OMRON
S2	Key selector switch	A22 TK series	OMRON
S3	Safety door switch	D4 series	OMRON
S4	Emergency stop button	A22E series	OMRON
KM1, 2	Contactor (mirror contact)	LC1-D09	Schneider Electric
KA1 to 5	Safety relay	G7SA-3A1B	OMRON
	Socket for safety relay	P7SA-10F-ND	OMRON
SRL1	Safety relay unit	G9SX-GS226	OMRON
SRL2	Safety relay unit	G9SX-BC202	OMRON
SRL3	Safety relay unit	G9SA-501	OMRON

3.2.3 Category 2

A safety circuit configuration example of category 2 is shown below.

Category 2 safety circuit example



*1: Wiring to check whether the controller is normal when using an alarm to shut off the main power

93315-Q6-00

Parts list

Circuit No.	Part name	Type No.	Manufacturer
S1	Reset switch	A22 series	OMRON
S2	Key selector switch	A22 TK series	OMRON
S3	Safety door switch	D4 series	OMRON
S4	Emergency stop button	A22E series	OMRON
KM1	Contactor (mirror contact)	LC1-D09	Schneider Electric
KA1, 2	Safety relay	G7SA-3A1B	OMRON
	Socket for safety relay	P7SA-10F-ND	OMRON
SRL1	Safety relay unit	G9SX-GS226	OMRON
SRL2	Safety relay unit	G9SX-BC202	OMRON

3.2.4 Overview of circuit operation

This section describes an overview of the circuit operation for each safety circuit configuration example shown in the previous sections.

1. During AUTO mode

The main power is supplied only when the enable switch is disabled, the controller is in a normal state (MPRDY is ON) with no internal alarms occurring, and also all the following conditions are met:

Conditions

- Maintenance mode switch is in AUTO (M1: open, M2: closed)
- Door switch's NC contact is closed.
- External emergency stop button's NC contact is closed.
- HPB-D emergency stop button's NC contact is closed.

CAUTION

Connect the HPB terminator or HPB-D to the HPB connector on the controller front panel. If the HPB connector on the controller front panel is open, an emergency stop occurs.

2. During maintenance

The main power is supplied only when the door switch is disabled, the controller is in a normal state (MPRDY is ON) with no internal alarms occurring, and also all the following conditions are met:

Conditions

- Maintenance mode switch is in SERVICE (M1: closed, M2: open)
- External emergency stop button's NC contact is closed.
- HPB-D emergency stop button's NC contact is closed.
- HPB-D enable switch's NO contact is closed.

CAUTION

Always disconnect the HPB terminator from the HPB connector on the controller front panel and connect the HPB-D to the HPB connector.

Revision record

Manual version	Issue date	Description
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Reference Manual

Robot Controller

Safety standards application guide

Aug. 2014
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